Social Aspects of Business Informatics

Concepts and Applications

Scientific Editors

Andrzej Marciniak
Mikołaj Morzy

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Preface

Contemporary Information Systems (IT) have found their applications in almost all domains of human activity. In particular, one cannot imagine any modern effective business environment that would not benefit from the introduction of IT systems. The abundance of technological, organizational and economical challenges posed by the utilization of IT systems in business has led to the emergence of a new scientific domain: Business informatics. Nowadays, IT systems for business aim at solving multiple problems, from decision support at the managerial level, through tactical decision making in highly competitive environments, to operational level trying to optimize various business processing.

In recent years a new paradigm has emerged from within the business informatics area, namely, the need to take into consideration social aspects of business environments. Many factors contribute to this paradigm shift. On the one hand, a huge success of social networks and the establishment of new business models (e.g. the f-commerce) has proven a high effectiveness of social media in marketing and analytics. On the other hand, as the web of interconnections between humans, companies, organizations and enterprises densifies, new opportunities for IT systems appear.

In this monograph we have collected several works by practitioners of business informatics. All these works discuss various social aspects of business informatics. We have divided the monograph into two parts. The first four chapters of the monograph present emerging concepts and discuss possible future uses of social networks, or social processes in general, in business informatics. The first chapter introduces the concept of an e-mentoring system which could facilitate the communication and the transmission of knowledge and experience in modern organizations. The idea of collaboration is further discussed in Chapter 2, where the author presents a concept of a meta-model for describing the process of collaboration in social networks. The presented meta-model uses a multi-layered view of social networks and information flows within these networks. In Chapter 3 the author introduces the concept of a multi-agent simulation environment which can help in rational time management, an issue of extreme importance in many business applications of IT systems. Finally, Chapter 4 is devoted to another fairly new concept in business informatics, telecommuting. However, contrary to most approaches the author focuses on weaknesses and disadvantages of introduction of the tele-work model in a company.

The second part of the monograph contains four chapters devoted to the presentation of applications of social concepts in business informatics. In Chapter 5 the author discusses the advantages of using the Shannon theory to the problem of character recognition. The solution presented in the chapter makes heavy use of the graph theory which is the basis of the social network analysis. Chapter 6 presents a very interesting application of the combination of data mining and image analysis techniques for biometric protection of electronic documents. The availability of lightweight biometric encryption mechanisms becomes an urgent need in the face of the general business trend of moving data and applications to cloud environments. Another modern application of IT systems which utilize social elements is presented in Chapter 7, where the author presents a thorough overview of eye-tracking application scenarios in business. The chapter discusses the fundamentals of eye-tracking and goes into several case studies of eye-tracking methods in different settings. The monograph concludes in Chapter 8, which contains a comparison of software packages used for EEG signal analysis.

The editors which to express their gratitude to the authors for willing to share the results of their work and writing chapters. We would also like to thank sincerely the reviewers - members of the Scientific Council of the Polish Information Processing Society. Their valuable remarks have helped to improve the quality of the monograph significantly. We hope that the readers will find the contents of this monograph both useful and inspiring, and that the presented chapters will help further explore the exciting synergy between social and business informatics.

Andrzej Marciniak, Mikołaj Morzy

Chapter 1

Concept of an e-mentoring system

The chapter aims at formulating a concept of an e-mentoring system linking mentors and mentees seeking inspiration and support in their business or career development activities. The idea behind this concept is to define a set of IT tools and accompanying processes to facilitate the communication, knowledge sharing and intellectual cooperation of mentors and mentees, taking into account the subsequent steps of building an e-mentoring relationship. There are numerous publications regarding e-mentoring systems but they either describe the outcomes of realized e-mentoring programs and activities, rather than the functionality of the underlying information system [KP13, Hea04, HCG06, WK11, DLSR10, Ntsh10], or focus on different aspects of an e-mentoring system than those proposed in this chapter [Dab11, IPMN08, HGC06, SM07, DRZM12, SMCDJ14, Phil14]. The latter ones are shortly referred to in the subsequent section.

1.1. Related work

Nicki Dabner presents an overview of the UC Live portal environment and analyzes the utilization of the tools, features and resources available through the portal by the students community [Dab11].

Maya Israel and others report in their paper the conceptual framework, cyber-infrastructure, and measures of effectiveness of a state-wide e-mentoring program at a Midwestern university. A combination of a course management system with open source components as well as synchronous and asynchronous communication is proposed, which enables mentees to access relevant resources, obtain immediate feedback from the mentors and other participants within the e-mentoring community, and engage in ongoing professional development [IPMN08].

Jenny Headlam-Wells with co-authors present in their paper an evaluation of the process of building and managing e-mentoring systems. The paper includes a diagram of the proposed site structure, including communication tools and resources [HGC06]. Sarah Stewart and Catherine McLoughlin describe the outcomes of applying an e-mentoring system using only an email tool [SM07], while Faten Damanhoori and others discuss the design of an e-mentoring system for Malaysian orphans, called MyMentorMentee.com. The system described in the paper consists of four modules: personal profile, text messaging, mentoring

schedule, and personal video chat. Snapshots of some parts of the interface are presented [DRZM12].

Puangpet Sriwichai with co-authors propose in their paper the "Knowledge Management System Based Mentoring" for sharing and disseminating research experiences of the senior staff to enhance the abilities of newly Ph.D. graduate staff in the universities to supervise Ph.D. students to get the qualified research outputs. The proposed system is a repository, providing the specific and professional knowledge and focuses on personnel development [SMCDJ14].

Nancy Philippart presents a conceptual model of an e-mentoring system and discusses three mechanisms connected with e-mentoring: mentor-mentee matching process, mentorship goal clarity and alignment, and mentorship support mechanisms [Phil14].

Applied approach

The approach applied to present and describe the functional structure and the users of the e-mentoring system is the object-oriented information systems analysis and UML use case diagrams.

Practical implications

The proposed concept of the e-mentoring system can be used as a starting point for further designing, constructing and implementing an e-mentoring system, which can support various e-mentoring programs. The features of the proposed system make it suitable to be used as the only means of communication and cooperation in an e-mentoring relationship, enabling synchronous and asynchronous communication possibilities, as well as visual and voice contact.

1.2. Definition and characteristics of online mentoring and the e-mentoring system

In recent years, researches on mentoring are interested in using information and communication technology to support traditional mentoring process and relationship. This is known as e-mentoring, online mentoring, tele-mentoring, virtual mentoring or cyber-mentoring [SMCDJ14]. E-mentoring can be also defined as a computer mediated, mutually beneficial relationship between a mentor and a mentee, which provides learning, advising, encouraging, promoting, and modeling, that is often boundaryless, egalitarian, and qualitatively different than traditional face-to-face mentoring. This definition has two elements that distinguish

e-mentoring from traditional mentoring: the boundaryless configuration of e-mentoring and the egalitarian quality of the exchange [BM02].

Depending on the proportion of personal to online communication and cooperation there are different types of online mentoring, differing in the range of CMC (Computer Mediated Communication) application: CMC-only (no face-to-face, personal meetings or telephone calls), CMC-primary (mostly online but occasionally personal meetings and phone calls occur), CMC-supplemented (mostly personal meetings with support of IT tools) [EHB03].

Online mentoring offers many opportunities as compared to traditional mentoring like: greater access (individuals without a large support group can access a community of like-minded individuals via the worldwide web, the Internet and computer-mediated communication provides mentors and protégés with a means to develop relationships with others free of limitations of convention, geography, time, or physical space), reduced costs, equalization of status, decreased emphasis on demographics, and a record of interactions [EHB03]. It also provides a context and exchange that may not be possible to replicate in face-to-face mentoring relationships. The nature of the e-mentoring relationship may be qualitatively different when mediated through a computer. E-mentoring programs promote both formal and informal online exchanges when a face-to-face relationship would be impractical. It has low barriers to entry, requiring Internet access, an email account, and minimal investments of time. It is highly time efficient and can be engaged in at the convenience of both the mentor and mentee. Further, large amounts of information can be exchanged in a short time span. While technology can be viewed as an impersonal approach, the medium promotes easier access and perhaps more candid communication than would occur face-to-face. The cultural baggage and stereotypes that accompany race, gender and social class become invisible in a virtual forum, freeing the mentoring to become the focus [BM02].

But the application of the virtual medium is also the source of certain challenges, which should be considered when implementing an e-mentoring system in a certain target group. The major challenges that can be identified are [EHB03, BM02]:

- requirements: access to computer technology, Internet and computer literacy, and competency in written communication,
- possible problems: computer malfunctions, miscommunication and delays in responses, lower commitment, issues of privacy and confidentiality, building trust and confidence, slower development of relationship than in face-to-face interactions.

Building an e-mentoring relationship should consist of the following steps: seeking desired mentor, sharing expectations, setting communication schedule (involving face-to-face for enhancing the relationship), fostering familiarity (share some background, personal information), seeking feedback concerning the relationship, summarize the relationship at its closure [BM02].

On the basis of the above definitions and descriptions of the e-mentoring relationship the following definition of the e-mentoring system can be formulated: an e-mentoring system is a set of online tools and processes that enable and support an interactive e-mentoring relationship between a mentor and a mentee. The e-mentoring system should enable execution of the mentioned steps of building an e-mentoring relationship, regardless of the focus of the mentoring relationship (academic or career success, or personal psycho-social development). Not all possible roles that a mentor can perform for the mentee may be equally easy and effective to realize in an online environment. That is why mainly the coaching role connected with learning, advising, encouraging, or promoting are supported by the e-mentoring system.

1.3. Assumptions and constraints of the e-mentoring system

E-mentoring system should enable and enhance realization of all subsequent steps of building, development and finalization of an e-mentoring relationship. Processes and supporting tools/functions for each step of development of the relationship are listed in Table 1.

Table 1. Tools and functions supporting e-mentoring relationship development phases

Relationship development phase	Supporting tools/functions/processes
seeking desired mentor	registering to e-mentoring portal, seeking mentor, establishing relationship
sharing expectations	e-mail, sharing basic profile information
setting communication schedule	e-mail, calendar
fostering familiarity	instant communication tools, sharing profile information
seeking feedback concerning the relationship	relationship management, knowledge base management
summarize the relationship at its closure	closing relationship, archiving relationship data

In the case of the proposed e-mentoring system, the matching of mentoring dyads is assumed to be based solely on the decision of the interested parties – in the first step the mentee chooses a mentor by analyzing the available information about him or her and sends an email to get confirmation from the chosen mentor. The second step is done by the mentor who confirms or rejects the relationship. Possibly other methods like those proposed in [SKL12] or [KYP12] could be used to enhance the matching results. As suggested in [HGC06] matching solely on the basis of mentees' needs and mentors' skills may not be enough to ensure successful matches, because personality factors are also significant. That is why the proposed e-mentoring system allows for sharing personal profile data to satisfy that need.
The chapter does not deal with the issue of recruiting participants to sign up to the e-mentoring system, which can be a problematic issue especially with regard to mentors, who must be willing to take time to share their knowledge. The aspects affecting individuals' willingness to engage in mentoring are discussed in [Ens13], where the author proves that the mentors will be more willing to engage in e-mentoring and more satisfied when higher presence forms of CMC are incorporated into interactions, and higher presence forms of CMC are generally synchronous communication tools. That is why these type of tools are part of the proposed e-mentoring system.
One more aspect which is not referred to in this chapter is promoting the use of the proposed system, which of course is necessary to reach all potentially interested individuals. Once fully developed the e-mentoring system could be used within some international project or program. It is also assumed that users of the system have average ICT literacy and need no support in that aspect.

1.4. Users and the functional scope of the e-mentoring system

Users of the e-mentoring system can assume one of the following roles: New User, Mentor, Mentee and Administrator (the role of the Administrator is ignored in the chapter because Administrator's functions regard systems maintenance and do not have direct connection with the e-mentoring relationship). New User is anyone who chooses to sign up to the e-mentoring system by sending an access request to register to the e-mentoring portal. The moment this person is granted access to the system they are no longer a New User but a Mentor or Mentee (depending on the role chosen in the access request). Both the Mentor and Mentee are users who have full access to the functions offered by the e-mentoring system. Table 2 presents functions available in the e-mentoring system associated with user roles.

Table 2. Functions of the e-mentoring system and associated user roles

Function\Role	Mentor	Mentee	New User
Registration to the e-mentoring portal			x
Establish relationship	x		
Seek mentor		x	
Display relationship data	x	x	
Close a relationship	x	x	
E-mail management	x	x	
Chat/video/VoIP conversation	x	x	
Display profile information	x	x	
Edit profile information	x	x	
Knowledge base management	x	x	
Calendar management	x	x	

The functionality of the e-mentoring system for the registered users can be grouped into the following modules:

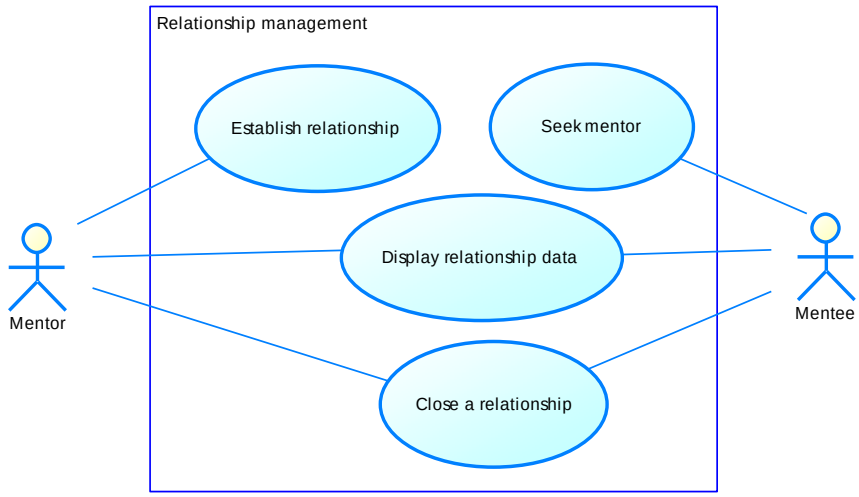
- **relationship management** – displaying information concerning the relationship and closing a relationship,
- **communication** – including the email management (creating, displaying, editing and deleting e-mails) and communication tools enabling real-time conversations (chat, videoconference and VoIP),
- **knowledge base management** – adding, displaying, modifying and deleting knowledge elements (based on wiki),
- **profile management** – displaying, modifying and sharing profile data,
- **calendar management** – adding, displaying, modifying and deleting events.

Additional functionalities supporting the primary functions include: searching, sorting and filtering. All the above mentioned functions of the e-mentoring system are presented in a form of use case diagrams in Figures 1-5, accompanied by tables with scenarios (main scenarios) of the presented use cases.

Registration to the e-mentoring portal
1. System displays a form to fill in.
2. User specifies his/her role and fills in the form,
   2a) if as mentor: personal data, expertise field (chooses from a pre-defined list), email, username, password,
   2b) if as mentee: personal data, fields of interest, email, username, password.
3. User confirms data.
4. System saves data, sends a register email.
5. After user confirmation creates new mentor/mentee account.

Fig. 1. "Registration to the e-mentoring portal" use case diagram with main scenario

Seek mentor

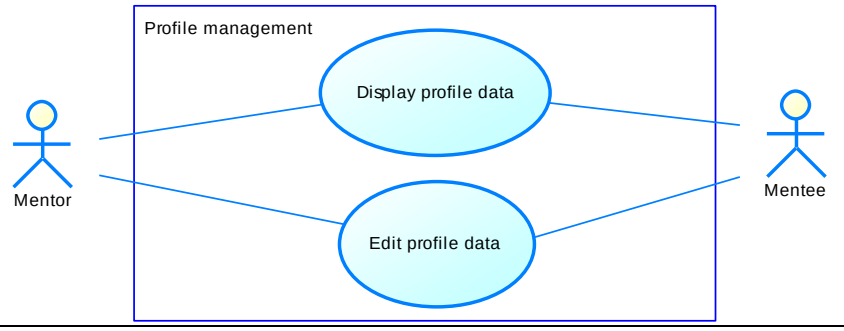


Pre-condition: Mentee has logged in successfully to the portal.
1. System displays a form for seeking mentor.
2. User fills in the form: topic of interest (a defined list to choose from), additional information, and confirms inserted data.
3. System displays a list of possibly matching mentors.

4. User chooses a mentor from the list. 5. User decides about sharing their profile data. 6. User confirms sending an introduction e-mail (template, which can be supplemented by additional data).
Establish relationship *Pre-condition: Mentor has logged in successfully to the portal and received a request e-mail from an interested mentee.* 1. Mentor chooses – Establish relationship. 2. System displays relationship creation form, with pre-filled fields (data provided by the mentee). 3. Mentor decides about sharing their profile data. 4. Mentor decides to send a confirmation e-mail (template with possible changes). 5. System saves data and creates a new relationship.
Display relationship data *Pre-condition: User has logged in successfully to the portal.* 1. System displays a list of all available relationships. 2. User selects a relationship. 3. System displays details (date of setting up, mentor/mentee data, topic, number of e-mails/events/conversations concerning the relationship).
Close relationship *Pre-condition: User has logged in successfully to the portal*. 1. System displays a list of available relationships. 2. User chooses the relationship to close. 3. System displays a template e-mail to be sent to the mentor/mentee. 4. User confirms sending of email and closing the relationship. 5. System sends the e-mail, closes a relationship and archives the relationship data (e-mails, chats, saved conversations, relationship details).

Fig. 2. Relationship management module use case diagram with main scenarios

E-mail client *Pre-condition: User has logged in successfully to the portal*. Standard functionalities of an e-mail client: receiving emails, creating and sending e-mails, additional features like: sorting, searching, organizing in folders.



Additional functionality: when a given relationship is chosen the e-mail box is filtered to show only correspondence associated to that relationship.
Chat/video/VoIP conversation *Pre-condition: User has logged in successfully to the portal.* 1. User chooses chat/video/VoIP conversation option. 2. System displays chat/video/VoIP conversation window.

Fig. 3. Communication module use case diagrams with main scenarios

Display profile data *Pre-condition: User has logged in successfully to the portal.* 1. System displays the profile data of the user.
Edit profile data *Pre-condition: User has logged in successfully to the portal.* 1. System displays a profile form. 2. User updates their profile information: personal data, background information or selects sharing options (decides about sharing profile data). 3. User confirms data update. 4. System saves profile data.

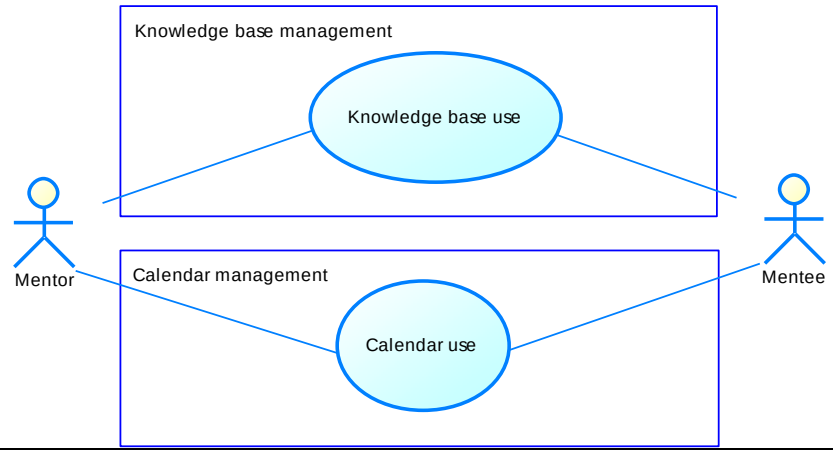
Fig. 4. Profile management module use case diagrams with main scenarios

Knowledge base use - CRUD type use case

Pre-condition: User has logged in successfully to the portal.

Mentor/mentee can: add new knowledge items, read existing knowledge items, update/modify knowledge items and delete knowledge items – wiki functionality.

Additionally a search engine is available and a possibility to share certain knowledge items with selected users.



Calendar use - CRUD type use case

Pre-condition: User has logged in successfully to the portal.

Mentor/mentee can: add new events (user fills in the form: start and end date and time, note, remainder, relationship reference), read existing events (with possible filter), update/modify events and delete events.

Additionally a filter is available for displaying details of events with reference to a certain relationship.

Fig. 5. Knowledge base management and calendar management modules use case diagrams with main scenarios

1.5. Conclusion

The idea behind the proposed e-mentoring system is to enable frequent and regular interactions between the mentor and the mentee, as this factor, along with mutual commitment, respect, trust, and comfort, determines mentoring success [BM02]. The aim of this chapter was to formulate a concept of an e-mentoring system linking mentors and mentees seeking inspiration and support in their business activities. It describes the functionality of the system and the underlying processes. Further research would concentrate on the physical design, construction and implementation of the e-mentoring system.

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Chapter 2

Concept of meta-model describing collaboration in social networks

Collaboration is a process in which two or more participants coordinate their actions toward achieving shared goals. Collaboration in a group of people gives a lot of benefits for participants, but it may also create many obstacles. Collaboration problems are common in many domains, including business and education. Nowadays, there are many different tools that support online collaboration, but the problems remain.

2.1. Introduction

Collaborative system is a system that supports communication, cooperation, and knowledge sharing between collaboration group members. There is number of methods to describe collaborative process [CB91], sustain collaboration environments [LHK03] or measure quality in collaboration [SVB10]. There were successful attempts to create dedicated collaborative systems (e.g. DCDS [Saf12], Alef [BSB14]), or to analyze data from existing collaboration processes using emails [BGD06], open source community behaviors [Gal01], software repositories [PSB11], execution logs from collaborative systems using Petri networks [WMD08], or heterogeneous (of humans and cultural objects) social networks [ADF14]. All these methods address analysis of collaboration in certain domain or in very abstract manner (e.g. Petri networks), but none of the presented has the capability to describe data from multiple, heterogeneous collaborative systems, and to build a social network from activities described in collaborative systems' execution logs built of both human and technical resources.

Burkhardt et al. [BDH09] propose a multi-dimensional method to describe the quality of collaboration in technology-mediated design situations; the collaboration quality is assessed in the following dimensions [BDH09, Table 1]:

- fluidity of collaboration;
- sustaining mutual understanding;
- information exchanges for problem solving;
- argumentation and reaching consensus;
- task and time management;
- cooperative orientation;

- individual task orientation.

Each dimension has its own indicators that can be measured. In real life, each of these dimensions may be realized by a different collaborative system. Separated analysis of each collaborative system's data gives fragmented view on measures of collaboration, and behavior of the involved people. That is why there is a need for new method that supports multiple types of analysis and gives aggregated measures from various collaborative systems.
In the following section we shall explain what are the problems with collaboration, gathering data from multiple and heterogeneous sources, and data analysis. In the next section, a layered meta-model is proposed that will allow to describe collaboration effectively and simplify the analysis of data coming from multiple and heterogeneous sources. The last section contains short summary.

2.2. Problem setting

Collaboration can be exemplified in working on a project, where many people collaborate to achieve planned goal. During work on projects, various participants' behaviors may occur. David Livingstone and Kenneth Lynch classified problems in education domain [LL02]:

- clever and lazy team members;
- unequal contributions from team members;
- group composition and each member skills;
- group unproductive time;
- impact on other work.

A similar concept is described in [HG01] as TeamWork Quality (TWQ) with six facets:

- communication;
- coordination;
- balance of member contributions;
- mutual support;
- effort;
- cohesion.

There are reasons to believe that the same problems occur in business domain – see, e.g., the work of Peter F. Drucker who pointed out similar problems in effective management [Dru06].

Nowadays, Information and Communication Technology tools are used to support collaboration and enable remote collaboration [NM08], which is crucial for the modern economy [Han10, pp. 52-60].
The IT tools supporting collaboration are known as collaborative systems. There is number of research papers categorizing collaborative and groupware systems, for example taxonomy in [MBM08], online suites in terms of features [Fic05] and system building blocks [RSV09, pp. 184]. In this chapter collaborative systems are categorized into the following groups:

- document management,
- version control,
- tasks and workflow management,
- communication and social networking.

Document management systems enable organizations to capture, integrate, and share knowledge buried in all types of documents [CC99, p. 46]. Version control systems allow the identification of items according to the naming and versioning schema, and their posterior evolution in a concurrent way [MWE10, p. 182]. Tasks and workflow management systems support management of material processes (involving interaction with physical objects), information processes (task performed by human with interaction of or by computer itself), and business processes (workflows, roles, acts) categorized in [MWF92]. Communication and social networking systems support online communication, conferencing, audio- and video-sharing, and publishing user messages with defined audience. There are cases where a system can be assigned to more than one category.
Categories described above are created because of the nature of data provided by those systems. Document management work logs register many small changes performed by the users, like inserting or removing text, applying formatting, and commenting. Data provided by version control systems describe changes applied to existing files (create, update or delete). Changes are grouped into change lists. Change lists can be committed, reverted or merged into multiple workspaces (e.g. code branches). Data gathered from tasks and workflow management systems are related to tasks, and actions perfumed of them: edits, changing state, and assignment. Data acquired from communication and social network source systems contain all information about user interactions, e.g.: who read (was participating in communication), changed or created any portion of data (via editing, creating comment, voting or sharing a link to the original material).

In order to illustrate these categories, some examples in business (software development area) and education domains are provided in Table 1. In business domain, enterprise class solutions are in common. Many companies can effort complex business suites from major vendors. In education sector, the major difference seems to be the price for using the collaborative system. Free to use, open source solutions, and services offered in a freemium model (where only the basic functionality is free) seem to dominate.

Table 1. An example of a table.

Collaborative system category	**Business**	**Education**
Document management	Microsoft Office Microsoft SharePoint Google My Business Atlassian Confluence	Google Docs Microsoft Office Online
Version control	Perforce Microsoft Team Foundation Server Git	Github SourceForge CodePlex
Tasks and workflow management	HP Quality Center Microsoft Project Atlassian JIRA	Moodle Evernote
Communication and social networking	Microsoft Lync, Yammer Atlassian HipChat Cisco Jabber	Facebook Twitter NK.pl (in Polish)

There is a problem with heterogeneous data and transforming them into a common format so that data from various sources could be combined. A relevant description model is needed, so that the quality of collaboration could be analyzed in various aspects and contexts (see e.g. [DBB10]). Furthermore, it is necessary to prepare data for analysis in a format required by one or more target data analysis tools. Finally, some guidelines would be useful regarding data analysis and presentation of its results.

All this combines into a very complex problem. In order to deal with this complexity we propose a layered meta-model: each of the layers addresses another component problem of the collaboration quality analysis. The proposed meta-model will be described in the next section.

2.3. Meta-model

2.3.1. Meta-model layers

In order to solve problems described in previous section, a meta-model is proposed. The meta-model provides abstraction of implementation techniques and technology tools, and defines separation of concerns using layers (see Figure 1). Each layer has clear responsibilities, and can be implemented by a different tool. Real-life applications can be built using models based on the proposed meta-model.

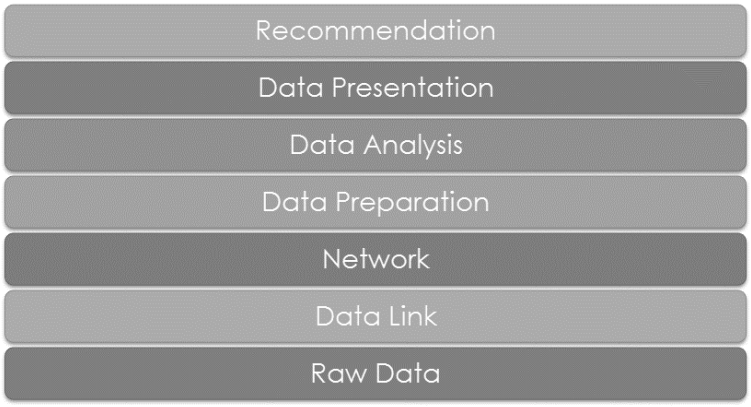

Figure 1. Layers of the proposed meta-model.
Source: Own work.

2.3.2. Raw Data Layer

The raw data layer is responsible for gathering data from source collaborative systems, including handling connections (when source collaborative system is a service), and data staging in local storage for further use. At this layer, data is stored in different formats (XML, JSON, Excel file, etc.), and with different identifiers describing resources. We address the problem of gathering data from diverse collaborative systems by importing data from collaborative systems' logs which contain information about user interactions in the system.

2.3.3. Data Link Layer

The data link layer is responsible for transformation and preprocessing of data. Transformation is done from source collaborative system data formats, to one common text-based format. After transformation is done, a preprocessing is

performed. Possible preprocessing steps include text parsing, text mining, and change categorization. The purpose of text parsing is to extract resource identifiers and tags (if any are relevant). Text mining is used for text categorization, sentiment analysis (opinion mining), and automatic summarization. Change categorization is applied to detect dominating type of change, for example formatting or text editing.

2.3.4. Network Layer

The network layer is responsible for aggregation of data, building network of resources, and validation of data. Aggregation is to connect same items that exist in multiple collaborative systems with different identifiers (e.g. at the same time one user might be identified by his/her email address, nickname, or full name, and task items can also have different identifiers in a collaborative source systems). All collaborative systems' logs are transformed into events. Event is a tuple of timestamp, actor identifier, action identifier, and action operands. Timestamp is time identifier when action was performed. Actor identifier (user resource identifier) is identifier of a person or system's account performing the action. Action identifier is representing action performed. There is a closed set of defined actions upfront. Action operands are identifiers of all the resources involved in a performed action. Exemplary resource types are: users, tasks, files, change lists, change types, etc.

> Example 1: "User commits a change consisting two source code files into trunk branch" is mapped into four events:
> *24-09-2014 10:00, user1, create change list, change list1, trunk*
> *24-09-2014 11:00, user1, add change file, file1, change list1*
> *24-09-2014 11:00, user1, add change file, file2, change list1*
> *24-09-2014 11:01, user1, commit change list, change list1, trunk*
> Example 2: "User comments a task" is mapped into an event:
> *23-09-2014 12:00, user1, crate comment, comment1, task1*
> Example 3: "User up votes a comment" is mapped into an event:
> *23-09-2014 13:25, user2, up vote, vote1, comment1*

Validation is to detect unexpected interactions between user resources and report possible issues to the analyst. Validation is implemented by a set of validation rules. Each validation rule takes parameters of validating event, and set of resources building the network. If an event fails on validation step, then error is reported to the analyst (e.g. a user assigned unknown status to a task).

2.3.5. Data Preparation Layer

The data preparation layer is responsible for selection of events and analyzing relations among events. Selection of events is performed to prepare data for analysis. Analyst may choose analysis target (e.g. task or file), or collection of resource types (e.g. task and users), and time gap (temporal analysis). Analyzing relations is performed to find or eliminate events, for example to detect transitive relations (if user1 merges change consisting changes on file1 to trunk branch, then user1 also works file1 in trunk branch). Rules for analyzing relations between events are defined in a dedicated grammar. Each analyzing rule is a function that takes an event as a parameter and returns a logical value. The result is true only if the event matches the rule. In such a case, the event is added to the set passed to the data analysis tool. Analyzing rules can be cascaded.

2.3.6. Data Analysis Layer

The data analysis layer is responsible for performing data analysis in a selected tool and importing results back into the model. An analysis is performed in steps, using functions, data formats and storage locations available in the data analysis tool. Data analysis tools are split into categories of social network analysis (SNA), process mining, and general data mining. For analysis of connections between users and resources, SNA is valuable. There is a number of SNA data processing tools, including UCINET, Pajek, Structure, NetMiner and StOCNET [Akh14], [Bor10]. Data mining tools can be used to find similarities between users or predict direction of collaboration. There is a lot of data mining tools, starting from SPSS, Oracle Data Mining/Data Miner, WEKA, RapidMiner, KNIME or even Matlab [MR11]. Collaboration groups (based on Open source movement) can be successfully analyzed as virtual organizations [Gal01] [Tor12]. Virtual organizations have their own processes, that can be analyzed using the PROM tool (e.g. using recommendation method RMV [Pas14]).

2.3.7. Data Presentation Layer

The data presentation layer is responsible for presenting data analysis results in a form of, e.g., pivot table, graph, chart or flowchart. In many cases data presentation tools are same as data analysis tools, for example Orange [DZL04].

2.3.8. Recommendation Layer

The recommendation layer is responsible for finding outliers (e.g. users doing the most and the least work in their category), comparison of flow across tasks or files and highlighting inefficiencies (e.g. tasks taking more time than others, tasks connected to many defects), users involved in process inefficiencies (e.g. clique, where all connected users work mostly with themselves). An analyst can define his or her own metrics to give synthetic results (e.g. percentage of interaction events performed by users in each group at a given process state).

2.4. Conclusions

The proposed meta-model for describing collaboration in social networks covers the entire data analysis process, end-to-end, while providing clear separation of concerns using layers. The meta-model is abstract of any specific data mining technique or tool. Our immediate future work is to prepare all required transformation rules and steps, so that models build using proposed meta-model could be easily transformed into executable data analysis toolkit, for example using Orange.

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Chapter 3

Multi-agent based simulation in supporting the working time management

Rational time management remains one of the still poorly appreciated factors influencing the increase of management efficiency. Time defines the essence and range of changes, including changes/transformations in the economic area, affects social and economic development and influences the quantity of produced goods and services. One may say that time is a regulator of economic and social mechanisms.

3.1. Introduction

If the frame of reference, in view of which time of a certain phenomenon or process is defined, is work, and more precisely changes occurring during the working process, then the quantitative aspect of this movement will be working time. It consists of this share of activities used by a person which appears mostly in the process of production and the provision of services. Working time is inextricably linked to work – it is the condition of its existence and its form of being [K92].

Growing competition in multiple dimensions and areas, including first and foremost the spread of internationalisation and globalisation, has caused the fact that some companies started to look for new ways to achieve competitive advantage. Time based competition has become one of them (the term "time based competition" was coined by Boston Consulting Group – BCG) and it consists mainly in practical application of time compression of basic manufacturing processes, especially taking into consideration production process and sales process. This time based competition has recently become a general development strategy for many companies [KP09].

Even a cursory glance at scientific publications allows one to notice that the question of time management covers a wide scientific range. Its individual issues are analysed from the point of view of various scientific disciplines. The majority of those issues concern macroeconomic problems, while others are examined in the micro scale, i.e. individual economic entities. In this article the wide scientific range has been narrowed down to the analysis of issues relating to working time management of workers in a company. The article presents an example of how

multi-agent based simulation is used to support working time management. The chapter briefly characterises multi-agent based simulation and defines the concept of an agent and its basic properties. A concept of a simulation model for working time management in a company is also presented.

3.2. The specificity of working time management

Nowadays, in times of the pursuit of profit and efficient action, the need to use modern, process-based and holistic methods of working time managements in companies is increasingly clear. Market dynamics make companies analyse their market position and, in consequence, draft plans of adapting to new market conditions, such as changing strategy, restructuring, modifying their products or services and introducing new ones, reducing production time and other processes which may affect making profits. The general trend is that those changes are to be implemented instantaneously or at least faster than before. Therefore Time Based Management (TBM) is becoming an increasingly popular practice. It is a modern management concept based on time, whose basis is the effective use of time in a company (e.g. in order to develop new products and launch them faster, to increase profit, etc.). Hence time is key value here, around which the whole system of managing processes in a company and its prospective results is built.

In practice, time-oriented organisation means that the attention of people responsible for proper implementation of company strategy (supervisors on any level of the organisation) will be concentrated on smooth processes, on carrying out tasks and, what is also important, on developing high-quality cooperation between particular departments of a company and even between individual employees. This is, among other factors, why effective company management requires defining clear and unambiguous objectives, developing functional action plans and supervising their progress. Appropriate definition of company objectives is the basis of effective working time management since: it helps to concentrate on specific tasks by particular departments of a company, allows to create long-term visions of the activities of the company, allows to make simulations of company's achievements, helps also to organise human resources by assigning tasks to individual employees and increasing their motivation to intensify their dedication to achieve common objective.

It is important to specify here how working time is defined. According to Article 128 of the Labour Code it is time when an employee remains at employer's disposal at workplace or any other place designated for performing work [U98].

The phrase that an employee remains at employer's disposal means that working time is also being ready to perform work and not only its performance at any given moment [B07]. Working time system is a set of principles connected to the organisation of working time admissible by labour law, which contains provisions concerning the norms of daily working time, weekly working time, accounting periods, etc.

In recent years one may observe more often and more clearly the opening gap between the quantity and rate of implementing technological advances and organisational changes on the one hand, and the range and rate of changes in working time system on the other. This creates an organisational gap, highly expensive for a company and economy. The widening of the gap becomes an ever bigger problem for Polish companies and institutions and its elimination – a significant scientific issue.

The starting point for indentifying and analysing the system of working time management in a company may be the general term of the management system of an organisation (e.g. company, institution). Management system means the entirety of measures, persons and practical actions referring to organisation's management and skills, regulating norms and formal or informal rules connected with it [KP09]. On this basis one may build a model of a working time management system, which may subsequently be expanded and specified for the purposes of particular companies (see fig. 1).

To summarise, proper working time management is key resource, crucial to the functioning of each company, institution or organisation. Precise definition of objectives, applying methods and rules of time management, identification and elimination of the so-called time-killers and systematic supervision allows for its effective use.

3.3. General characteristics of multi-agent based simulation

Computer simulation is a method with a wide range of application in multiple fields of science. This method consists in creating a simulation model of an object or system in the form of mathematical and logical notation and presenting relationships describing the simulated object or real system and its environment in such a way that these relationships may be studied by changing the input signals and model parameters. Computer simulation is a method of reproducing phenomena of the real world with the use of their mathematicised models defined and operated with the use of computer programmes [MPK13].

Multi-agent based simulation (MABS) is one of the simulation techniques which has gained a lot of popularity in recent years as a method of supporting decision-making. Until the early 2000s, agent based modelling was pretty much an academic topic. The adoption of agent-based modelling by simulation practitioners started in 2002-2003 [B13]. Agent-based models are created in order to solve problems in many areas, including company management [S11]. Each contemporary company has to manage communication and information exchange with their clients, suppliers and employees, needs to manage its assets and plans, and also ensure control over the circulation of internal information concerning their offered products and/or services. In each of these actions MABS may prove helpful. This article describes the application of MABS to support working-time management.

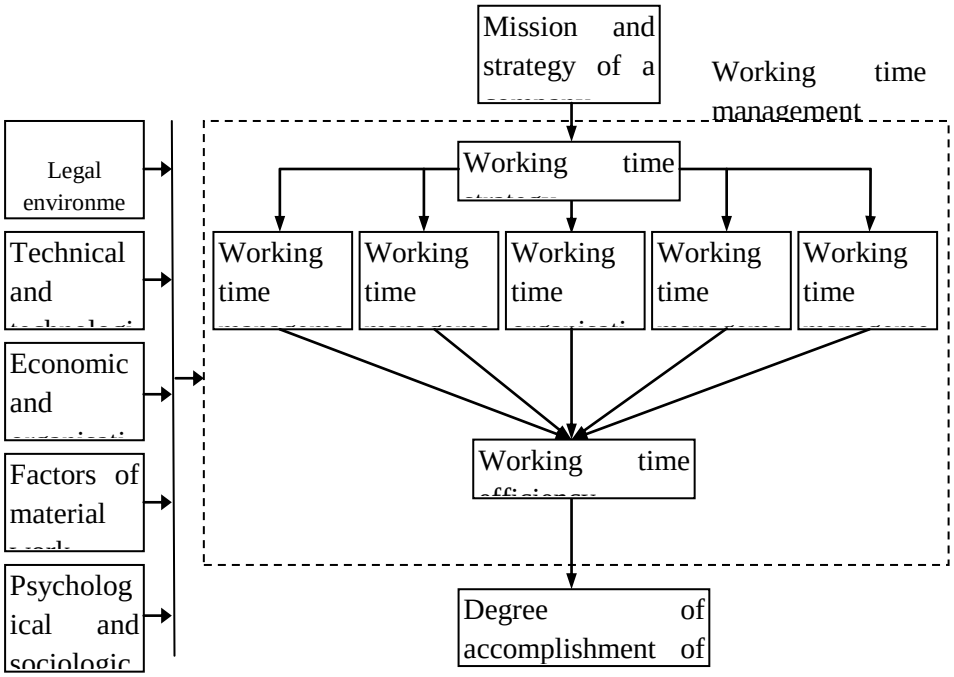

Figure 1. A model for working time management in a company

Source: author's own elaboration based on [KP09], p. 345345.

In MABS the studied system is modelled as a set of autonomous units, called agents (the notion of agent and its basic characteristics will be defined in the next passage). In a multi-agent model, decision-making processes in micro-scale are

described for each agent individually. An image of a studied phenomenon in macro-scale results from connecting actions of multiple agents and their interactions with one another [SA08]. The use of MABS means that a certain modelling procedure is observed (for a full description of a multi-agent modelling procedure see [ŁWWF12]). It starts with formulating the problem and setting out the objective. The next step is to define the simulation environment in the studied area (including, most of all, agents, space and environment) and to specify the system borders. The next step of the procedure is connected with the issue of obtaining input data for the model. For the person conducting the study it is a key stage as an incorrect choice of the method of gathering information may prevent them from meeting the objectives of the study. Then, on the basis of data gathered, one may start constructing multi-agent based model of the analysed system. The starting point in conducting MABSs is the initialisation of a certain population of agents. It consists is defining the attribute values of agents (their internal states), rules of behaviour and the principles of communication between them. The next stage of multi-agent based modelling procedure is carrying out the computer simulation, i.e. starting the simulation model. The results of a simulation (so-called base course), illustrating the behaviour of a studied system in time, are compared with the available data on the system and the model is verified, if need be. The model is verified as long as it satisfactorily reflects the real behaviour of the system. The next stage of the procedure at hand is the simulation of effects of potential changes in agents' behaviours (including simulation experiments). Then the results of the base course are compared with results of experimental courses, and analysis and assessment of simulation results is made (statistics methods are most frequently applied for this task). The last step of the procedure is formulating conclusions of the study.

In the past few years there has been a considerable development of multi-agent based modelling and simulation software. Simulation packages have become more complex and universal. Currently the market offers various simulation programmes, starting with the simplest, based on mathematical models (e.g. NetLogo, Repast) and ending with the most developed, with stochastic system allowing to adapt input data to the right distribution, with an environment for creating animations, 3D images, multiple tools for presenting the output of a simulation (e.g. AnyLogic).

3.4. Characteristics of agents

In 1980s the notion of an agent began to take shape, as well as a certain set of its characteristics. However, it is still difficult to find in academic papers a generally accepted, universal definition of an agent. Wooldridge and Jennings define agent as a computer system situated in an environment and capable of operating autonomously to perform their actions, necessary to achieve their goals [B06] [WJ95]. Figure 2 presents an abstract agent model in which the agent observes its environment and generates actions shaping this environment.

Many articles present various descriptions of what characteristics should an agent have. For example, typical characteristics of an agent compiled by Franklin and Graesser [FG96] are presented in table 1.

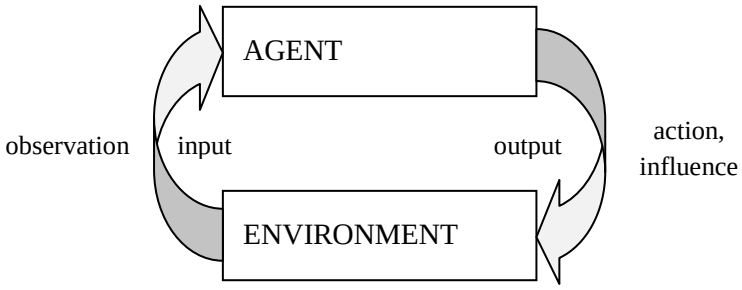

Figure 2. Agent and its environment

Source: Author's own elaboration on the basis of [B06], p. 13 and [W02], p. 16.

To summarise, one may assume that an agent has the following characteristics [MN06]: (1) it is an identifiable unit with a set of certain characteristics and principles governing its behaviour and decision-making abilities; (2) it is situated in an environment in which it interacts with other agents; (3) its action may be goal-oriented; (4) it is autonomous, may function independently in its environment and in contacts with other agents, at least in certain predefined situations; (5) it is flexible, has the ability to learn and adapt.

Table 1. Typical characteristics of agents

Property	Other name	Meaning
Reactivity	Feeling and action	Reacting to changes in the environment
Autonomy	-	Control over their actions
Goal orientation	Proactivity	Not simply acting in response to their environment
Continuity	— -	Continuous process
Communicativeness	Social ability	Interacting with other agents and also humans
Learning, mobility, flexibility	Adaptability	Adaptive changes in behaviour based on previous experience, ability to move, action based on personality and emotions, and not on scripts

Source: [D10], p. 353.

One should underscore here that agents in simulation models may represent various objects: vehicles, items of equipment, designs, products, ideas, organisations, investments, people in various roles (e.g. consumers, suppliers, employees), etc. [B13] The next section of the article describes an example of how MABS can be used to support the working-time management, in which agents represent employees of a company.

3.5. A concept of simulation model for managing working-time in a company

Assuming the general model of working-time management system in a multi-dimensional approach as the starting point, one may develop a simulation model which will be created and detailed for the purposes of a particular company. For the purposes of the study it has been assumed that a hypothetical company offers its services consisting in renting equipment, machines, scaffolding and cranes for construction industry. It employs a permanent working force (50 employees), qualified both to install and to repair the machines. Devices are installed and repaired with intensity proportional to the number of employees delegated to installations and repairs. The management of the company tries to delegate as many employees as possible for installation works to clients (as it generates profit for the company). Delegating employees to do repairs happens when a machine failure occurs – the intensity is proportional to the number of broken machines. The repair takes place in the seat of the company and lasts some time (2 hours on

average), after which employees return to installation works, which are the priority of the company.

Service system consists of a team of technicians who begin their daily work in company's office and then leave for their clients, according to the list of commissions. In their work they use company's IT system which has a separate Service module. This Service covers the control of all actions, connected with providing technical service for machinery rented by the clients. It allows registering all performed installations with their technical descriptions, the activities of technicians, performing technical review and repairs, monitoring financial settlements, registering and analysing costs. Thanks to cooperation with this module, technicians may be up-to-date with commissions entered into the system and accept them for realisation. Thanks to the access to the system via the Internet, after an installation is finished at client's place, each of the technicians may check what other commissions are queued and, depending on the situation, go to another client (perform an installation of a rented machine) or, in case there are no installation commissions, return to the office (to attend to potential repairs).

In the proposed MABS model, each of the 50 employees is an agent. Agent's behaviour is relatively simple: receiving a commission, ride to the client, installation of the machine, return to the company and carrying out next commission or repairing a malfunctioning machine. This can be illustrated by five states in which an agent can be: *Waiting*, *Ride to the client*, *Installing*, *Return to the company*, *Repair*. Transition between these states is dependent on certain occurrences. Transition from *Waiting* depends on the occurrence of a failure. If there is no failure, a technician receives an order to provide an installation service at client's place – i.e. the agent transitions from *Waiting* to *Ride to the client* and then is in the *Installing* state. Once the installation is finished, the technician comes back to the office – i.e. transitions to the *Return to the company* state and again enters the *Waiting* state. If, however, a failure occurs, the technician remains in the company's office and engages in repairing the machine – i.e. the agent transitions to the *Repairing* state, and after the repair is finished – again to *Waiting* (see fig. 3).

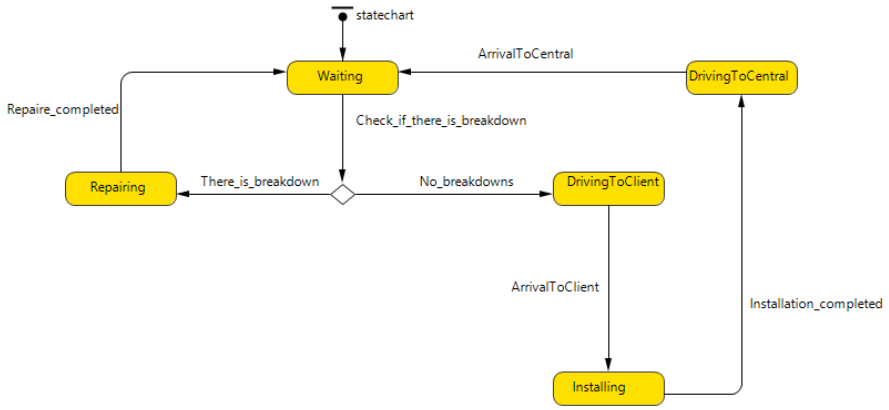

Figure 3. Main diagram of the states of employees

Source: author's own elaboration.

As mentioned above, one of the key characteristics of agents is their ability to communicate. In the model at hand this aspect has also been included. All instances of communication between agents and other objects may be divided into four types:

- technician's arrival at the client's: a message sent from an agent to the client,
- completion of installation: a message sent from an agent to the IT system of the company,
- completion of repair: a message sent from an agent to the IT system of the company,
- checking whether any failures occurs: message from the "central dispatcher" (here: the IT system of the company) to all agents-technicians.

In the analysed simulation model the environment of an agent may be described as two-dimensional space 100 km by 100 km. Therefore we assume that each agent can service a client within 100 km from company's office (if it is located in the centre of this area). Because of necessary simplifications, the model does not include roads, the only assumption is that agents travel in straight lines in all directions within the radius of 100 km during an 8-hour working day and the mean speed is 60 km/h (fig. 4).

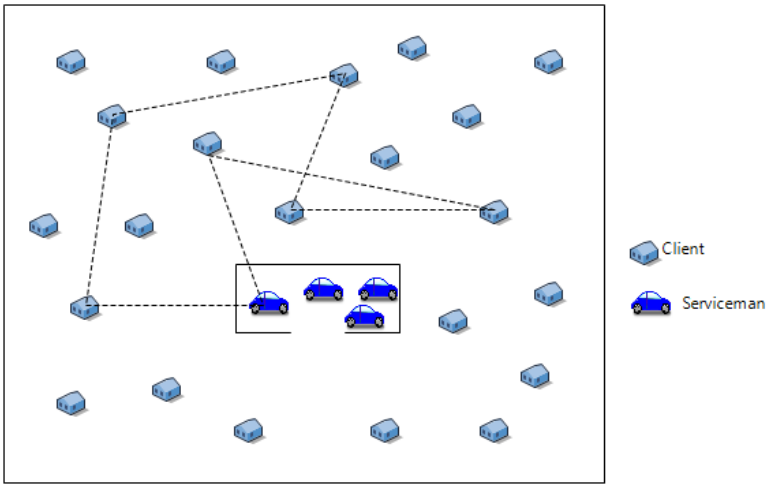

Figure 4. The space of a simulation model for working-time management

Source: author's own elaboration.

According to the adopted multi-agent based modelling procedure, the next stage was conducting a computer simulation, i.e. launching simulation model (due to the breadth of the subject in the article, the description of technical details connected to constructing a multi-agent based model in AnyLogic system was omitted). The results of the simulation were subsequently statistically analysed and on the basis of this analysis, charts illustrating evolution of certain phenomena in time were generated. For instance, Figure 5 presents simulation results for 6 weeks. The stacked chart shows the number of employees engaged in performing basic activities connected to work, i.e. installing machines and devices at client's (*Installing*), repairing broken machines and devices (*Repairing*) and waiting for another commission (*Waiting*).

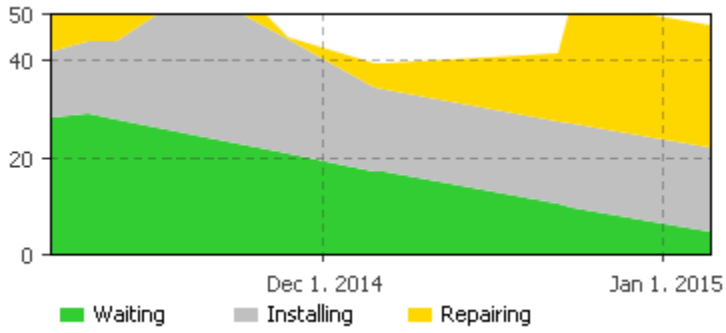

Figure 5. The engagement of employees in performing basic tasks (time of simulation: 6 weeks), Source: author's own elaboration.

3.6. Conclusion

The article presents an example of how multi-agent based simulation may support working-time management. A concept of a simulation model has been described, pointing to its main aspects and their respective determinants. While creating it, both strategic and operative approaches have been taken into consideration. Strategic approach to working-time management means here a situation whereby a company aims at connecting working time with its strategic objectives, thanks to which it becomes an important tool supporting the process of the adaptation of the company to the changes in market and consequently increasing the competitiveness of the company.

Thanks to the ideas presented in the article one may draw the conclusion that MABS is a method which may be and is used successfully to support working-time management. One may conduct a virtually unlimited number of experiments in a short time using the simulation model built according to the proposed procedure with an appropriate simulation package (e.g. AnyLogic, Swarm, NetLogo); this allows to examine the influence of many factors on effective working-time management of employees of a given company.

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Chapter 4

Dysfunctions of telecommuting

The cognitive purpose of this chapter is the analysis of weaknesses of introduction of the telework model in a firm. In the chapter, the author advances the thesis that the performance of employees' duties outside the company's office is connected with several psychological and communication dysfunctions. Although many employers recognize numerous advantages of teleworking, such as cost savings, most of businesspeople are hesitant about whether to allow the possibility of executing orders outside the company's office. Finally, they refrain from taking this step as they realize the existence of serious shortcomings of the model, influencing the quality of work which may result in suffering substantial losses.

4.1. Introduction

Polish employers are dubious about the advantage of benefits of teleworking. Business owners are worried that lack of direct control over their employees will affect their conduct and at the same time create an ideal environment for abuse. Barriers to introduction of teleworking in the company and problems related to introduction of this model in the firm exist despite the significant development of ICT which it might seem to fully compensate for the absence of face-to-face contact. Man, as a social being, feels fulfilled living in a social group, not in isolation.

Telecommuting leads to increased risk of abuse and misconduct due to introduction of flexible solutions in the company. In this context, remote work entails many threats to the company's development. The author has analyzed the current situation on the Polish labor market, paying special attention to industries in which the telework model is used most often. Research methods used by the author include statistical data analysis and observations.

4.2. Definition of Telecommuting

Telecommuting involves changing spatial structure of the company and allows the use of different forms of flexible work arrangements within the employment relationship. It requires properly selected tools that support the users so that they can work together on specific projects and let them feel slightly as if they communicated with each other in the workplace. Workplace flexibility means the

ability to adjust the size and structure of employment to changing conditions, situations and needs of the company. It is achieved mainly by changing regular employment for temporary employment, which has an impact on cost rationalization. Teleworking refers to any kind of intellectual work performed by an employee of a certain company outside the traditional workplace, and then transformation of partial results of work using information technology tools [1]. The terms that are directly related to teleworking are: mobility, flexibility and individualism. This solution could not exist without the ICT network that is used for exchanging information and communication between all employees of the company.

Telecommuting is a modern solution that focuses on the results not the duration of work. Dynamic development of new technologies has made the employers representing such sectors as IT or e-marketing opt for teleworking, recognizing several mutual benefits of the model. The existence of information society is not dependent on computerization which is only a tool of the process of modernization of public administration and will never decide on the development of information society - it cannot be regarded as a priority. The information society is built starting from changing the awareness of an individual realizing the role of knowledge based on reliable information. The public information itself should learn modern management techniques of the resources of the organization, with an emphasis on quality. The basis for such changes should be constituted by employees who are well-aware of their role [2].

4.3. Managing teleworkers

The current trend involves the concept of work management, which is a tool used for managing tasks and work based on cooperation and mobility in project coordination. Therefore, telecommuting is connected with making various changes in human resource management and such changes are associated with the use of new forms of interpersonal communication, establishment of working time and control of assigned tasks. Recently, it has become necessary to find new solutions for controlling employee efficiency. An example of such tool is a work performance sheet, i.e. a document used for recording time when employees start and finish their work. Its function is to facilitate the calculation of remuneration of employees and the amount of cost of production of a particular product or delivering a given service. The work performance sheet contains several key elements such as: detailed description of a given order, quantitative requirements,

workplace, date and time limit within which the task is to be done. The document also includes details of a person or persons who perform a given task. Thus, if a manager has no direct contact with an employee and cannot directly supervise his or her activities, the manager has to take into account that the employee betrays his or her trust and forges data entered in the work performance sheet, distorting the valuation of one manhour, which consequently results in the increase in the cost borne by the employer in respect of work orders performed outside the company's office.

Telecommuting is also connected with changes in the exchange of information between employees. Phone calls are a form of communication that does not meet all expectations of teleworkers. Therefore, employers try to find other tools to improve communication. An indispensable element of teleworking is reporting performed tasks. The effects of work are usually attached to emails. Telecommuting requires that working time is synchronized with other members of the project team, which is very difficult to achieve.

One of the most important functions of a manager is the delegation of new tasks. Teleworkers use virtual boards on which orders are placed and assigned to individual employees. It is possible to add tasks, comments, or files from an employee's own computer and to vote to choose the winning concept for the task implementation. The barrier to implementation of innovative solutions is teaching employees how to use programs used for non-standard forms of communication. The company must ensure that employees have the right equipment needed to perform their duties along with the installation, repair and training. It is possible to execute orders using the employee's own tools. In this case it is necessary to draw up an appropriate annex to the employment contract specifying the terms and conditions of lease. Teleworkers have then the right to financial equivalent of depreciation, i.e. wear and tear of the equipment. Another obstacle is the high cost of using the program dedicated solely to teleworkers combining the most important functions of the tools used in teleworking. By analyzing the functions of the dedicated tool, the author draws the conclusion that product marketers artificially induce the need to purchase the program, which combines functionalities of 2 or 3 well-known, free tools, i.e. e-mail or calendar. Developers of new technology try to convince teleworkers that they attempt to meet the need for communication and remote work performance supervision system.

If staff carry out their professional duties outside the office, they must take special care of security, reliability and confidentiality of information stored. Even carrying a laptop to a meeting with the employee's manager may be associated with the risk

that the data stored on the computer is damaged due to mechanical factors or even stolen, e.g. when using means of public transport. The risk of a similar event is much lower for work performed in the office. Another threat is concerned with the performance of professional duties in public places e.g. in cafes, where an unauthorized person may have access to the database, e.g. the CRM system. There is the risk that the employee will connect to an unreliable network and fall victim to hackers. The equipment which is used by the employee performing the tasks assigned to him or her, is also often used for other purposes such as entertainment or searching for information on the Internet. The equipment is also used by his or her family which does not support data security.

4.4. Psychological barriers to telework

Another problem is the alienation of individual employees having no face-to-face contact with other team members. Such isolation can have negative health effects: anxiety or depression. If an employee does not participate in team building meetings, he or she gradually grows apart from other employees, which has a negative impact on other interpersonal relations, e.g. in the family. The employee has no motivation to work as he or she does not see his or her colleagues carrying out their tasks. He or she has no opportunity to talk about their ideas in order to exchange views and receive constructive criticism. These employees often do not feel the need to mix with other people as they gradually get used to working alone. The situation described above causes problems with establishing contact with new people they meet in their private and professional lives. Consequently, this leads to anomie, i.e. the breakdown of social bonds.

The alienation of employees is also a significant loss for the employer. The employer cannot ask employees to brainstorm to take advantage of the potential of each employee. The confrontation of ideas can help create brilliant concepts. Synergy involves understanding that employees forming teams are communities of learners and they have two contradictory qualities. On the one hand, they are the result of egalitarian beliefs that treat everyone as an individual in the spiritual sense of an equal value, on the other hand, people who make up the organization are different from each other [3]. Therefore, telecommuting partially destroys creativity which is boosted when people with different competencies meet.

The isolation of employees also results in the loss of organizational culture as there are no rules of behavior required in certain circumstances. E. Schein defines organizational culture as a pattern of basic assumptions - invented, discovered or

developed by a given group in the process of learning, solving problems of external adaptation and internal integration - functioning well enough to be considered right and adequate to be forwarded to new members of the community as a proper way of recognizing, experiencing, and responding to these problems.

E. Schein identifies three levels of organizational culture.

- *basic assumptions*, which constitute the essence of culture, giving rise to other culture components, corresponding to problems of existence, human nature, reality and truth,
- *espoused values* which constitute more observable level of culture, more than the previous one, manifesting itself through the views and attitudes of members of the organization,
- *artifacts and products*, which constitute a visible component and indicator of organizational culture, i.e. the so-called material culture of the organization. They include organizational structure, procedures, systems and organizational behavior patterns. Observable also at this level, behavior patterns, rituals and myths are indicators of culture [4]. Thus, telework causes moral losses. The employee does not have a chance to learn behavior patterns acceptable in the company or the opportunity to demonstrate their ability to assimilate such standards and put them into practice.

On the other hand, employees working from home are sometimes distracted by home environment which makes them unable to concentrate. Many teleworkers try to combine their household chores with performing tasks assigned to them by their manager, which results in the decrease in their efficiency. Very often home environment does not meet basic ergonomic requirements. Employees tend to sit on the sofa, which, after a few hours of work has a negative effect on their back and other parts of their body. The line between work and leisure is gradually blurred, making employees spend more time trying to find ideas for implementation of tasks which, paradoxically, does not translate into greater efficiency and quality of work. Teleworkers become mentally tired due to their permanent availability. Checking their email non-stop is the first step on the road to workaholism.

Despite its unquestionable benefits, i.e. cost savings for employers, telecommuting is not a proper model for every industry, which constitutes another barrier to its introduction. In 2013, the research company PBS DGA conducted a study on telework in Poland. It turns out that every seventh company decides to hire remote

staff or creates all necessary conditions to perform such work. Most often these are companies operating in the financial, accounting or IT sector. Very often teleworkers are graphic designers, programmers, architects, editors, translators, journalists, website administrators, marketers, lawyers and IT specialists. Paperwork usually gives the opportunity to organize the remote work system. There is also a possibility to combine regular work with telework. This means that, for example, an employee comes to the office only once a week, and the remaining days he or she works from home, transferring their work results to the supervisor via remote communication channels. However, not every kind of work can be done this way. Professional machinery and equipment support, or customer service require that the employee is present in the workplace [5]. Finally, it should be emphasized that not every employee is able to telework. Only those who are individualistic and those who are easily distracted by talking to their colleagues are good candidates for teleworkers. Other important qualities of teleworkers include loyalty, conscientiousness and sense of responsibility.

4.5. Conclusion

To sum up, an employer who considers the possibility to introduce the remote work option should think about possible profits and losses. The employer fears that it could lead to abuse on the part of an employee who dishonestly calculates his or her working time. The risk of suffering losses due to the implementation of teleworking is high. Experienced entrepreneurs cannot imagine lack of everyday direct face-to-face contact with their employees. Perhaps this is due to the fact that they value non-verbal communication that allows to read true intentions of the person they talk to. The author of this paper has proven that the existing psychological and communication barriers support the performance of tasks in the conventional way, except for professions which allow to perform duties outside the company's office without substantial risk of abuse or misconduct on the part of the employee. The main disadvantages from the point of the employer are: limited ability to control employee's activities, costs associated with the purchase of computer equipment and the requirement to have adequate technical background in the company. The employees, however, often mention the following disadvantages of teleworking: increased need for contact with colleagues, blurring line between work and leisure and the possibility of hardware failure which hinders contact with the supervisor. The significance of numerous weaknesses of teleworking weighs against the model, however, in any case one should consider the broader picture to

evaluate all necessary circumstances: industry, position, workload, the employee personality, budget, etc. The analysis shows that telecommuting is not a model that a priori can be considered as the most favorable one.

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Chapter 5

On practical application of Shannon theory to character recognition and more

Let us consider an optical character recognition system, which in particular can be used for identifying objects that were assigned strings of some length. The system is not perfect, for example, it sometimes recognizes wrongly the characters "Y" and "V". What is the largest set of strings of given length for the system under consideration, which can be mutually correctly recognized, and the corresponding objects correctly identified? It is not the only interesting question that can be asked. In 1956, Shannon posed a problem of determining the capacity named after him [S56]. It is interesting that the formalism, which he introduced, can be used for describing the aforementioned problem. Moreover, many important problems can be represented using the formalism of Shannon. In this chapter we present results of combinatorial information theory concerning the problems briefly described above.

5.1. Shannon's theory

By a *graph* G we mean an ordered pair of sets V and E such that the set E consists of two-element subsets of V. The elements of the set V we call *vertices* of a simple graph G, and the elements of the set E are called its *edges*. If, at the same time, we want to indicate that the given set is the set of vertices of the graph G, then we write $V(G)$. Analogically we write for the set of edges. Let us consider a graph G. If v, w are elements of $V(G)$ and $\{v, w\}$ is an element of $E(G)$, then we say that v is adjacent to w. A set of vertices S of G is said to be an *independent* set of vertices if they are pairwise nonadjacent. The *independence number* of G, denoted by $\alpha(G)$, is defined to be the size of a largest independent set of G. The *degree* of a vertex v of the set $V(G)$, denoted by $d(G,v)$, is the number of all vertices adjacent to v. The *complement* of a graph $G = (V, E)$ is a graph G on a set of vertices V, the set of edges of which is $[V]^2 \setminus E$.

Given two graphs G and H, we define the *strong product* $G \boxtimes H$ as follows. The vertices of it are all the pairs in the Cartesian product $V(G) \times V(H)$. There is an edge between (x, x') and (y, y') iff one of the following holds: $\{x, y\}$ is an element of $E(G)$ and $\{x', y'\}$ is an element of $E(H)$, or $x = y$ and $\{x', y'\}$ is an element of

$E(H)$, or $x' = y'$ and $\{x, y\}$ is an element of $E(G)$. Shortly, we write $G^{\boxtimes p}$, what means $G \boxtimes G \boxtimes ... \boxtimes G$, where G appears p times.

Let X and Y be random variables, and let X and Y be the corresponding codomains. Let us consider a discrete model of a noisy channel. In this model, the sets X and Y are finite. In each unit of time, the channel receives one symbol X from the input alphabet X and returns a symbol Y from the output alphabet Y. *A discrete noisy channel* in such model is an ordered triple $(X, Y, P_{X|Y})$, where $P_{X|Y}$ is the set of probabilities $p(Y = y|X = x)$, shortly $p(y|x)$, denoting the probability of receiving a symbol y from the set Y, if a symbol x of the set X was sent.

We now shortly describe a faultless data transmission by a discrete noisy channel [SB56]. Let $W = (X, Y, P_{X|Y})$ be a channel. Let us consider a single use of it. The set of symbols, which can appear in the output, if the input is the character x, is given as $S_x = \{y : p(y|x) > 0\}$. *The characteristic graph* of a channel W is a graph $G(W) = (V, E)$, shortly G, such that $V = X$ and $\{v, w\}$ is an edge from the set E if and only if the sets S_v and S_w are not disjoint. Less formally, two vertices (symbols) in the characteristic graph are adjacent if they are indistinguishable, that is, can be mistaken by the receiver. Let us observe that for a given channel W, while using it once, the largest number of symbols mutually distinguishable is determined by the independence number $\alpha(G)$. Now let us consider using the channel twice. The receiver can mistake two sequences of vertices (symbols) vv' and ww' if one of the below three conditions is satisfied: v' can be mistaken with w' and v can be mistaken with w, or $v = w$ and v' can be mistaken with w', or $v' = w'$ and v can be mistaken with w. Therefore these strings are indistinguishable for the receiver. Moreover, these are the same conditions, which are present in the definition of the strong product, and the largest number of the input strings distinguishable for the receiver in this case is equal to $\alpha(G^{\boxtimes 2})$. Extending the above reasoning, while using the channel W p times, the characteristic graph is the pth strong power of the graph G, that is, $G^{\boxtimes p}$. Similarly, the largest number of input strings distinguishable for the receiver equals $\alpha(G^{\boxtimes p})$. Thus while using the channel p times, the amount of information, which can be transmitted by the channel is $\gamma(p) = \log_b(\alpha(G^{\boxtimes p}))$, where b is a positive integer greater than 1. In 1956, Shannon defined the zero error *capacity of a noisy discrete channel* W with the characteristic graph $G(W)$ as $C_0(G(W)) = \sup_p \gamma(p)/p$. Sometimes the capacity is defined as $C'_0(G(W)) = \sup_p(\alpha(G^{\boxtimes p})^{1/p})$.

5.2. Practical scenario

Gärtner and Matoušek [GM12] in their work considered the problem of digitizing books. They combined in this way the theory of Shannon with character recognition systems. They posed, according to them, a theoretical problem, which was based on specifying the cardinality of a largest *k*-letter dictionary, in which any two words from a digitized book could be scanned and unmistakably recognized. We found a realistic scenario, which can be used for identifying objects.

Let us consider a device *U* registering a string of length *n* from an alphabet *A*. The device, for example, registers the caption on a package of a product. Next, the caption is used for identifying the product. Thus the production engineer must take the following two decisions. How can we denote objects using *n* characters in a way such that the recording device does not make a mistake while identifying products? What length should have the string in order for the number of codes to suffice to mark all items? Let us consider the alphabet A = {"E", "Ę", "F", "Y", "V"}, which, for the clarity is reduced and contains upper-case letters of the Polish language. Suppose that the device mistakes "Y" and "V" or "E", "Ę" and "F". The remaining letters are recognized correctly. Then we obtain a characteristic graph H consisting of the vertices {"E", "Ę", "F", "Y", "V"} and edges {{"Y","V"},{"E","Ę"},{"E","F"},{"Ę","F"}}. Let us observe that in the general case, the characteristic graph and the possible errors can be tested empirically for a given device. Similarly as in the earlier considerations on the Shannon capacity, the set of codes (captions) that can be applied has cardinality at most $\alpha(G^{\boxtimes n})$. For example, for $n = 2$ we have $\alpha(H^{\boxtimes 2}) = 4$. We can choose for example the strings ("F", "V"), ("V", "Y"), ("Ę", "E") and ("Y", "F"). We cannot additionally choose, for example, the string ("F", "F"), as it can be registered as ("Ę", "E"). What is interesting, if the characteristic graph is a cycle on five vertices, then the largest number of codes of length 2 for marking the objects is 5 [S56]. Let us consider the alphabet A = {"Ó", "O", "0", "D", "Ő"}. Suppose that the letters "Ó" - "O" - "0" - "D" - "Ő" - "Ó" create a cycle of length 5. Then the largest set of strings of length 2 is for example the set {("Ó", "Ó"), ("0", "O"), ("Ő", "0"), ("O", "D"), ("D", "Ő")}.

It is worth to note that in the aforementioned scenario, we do not add redundant information, for example extra letters that could be a method for detecting distortions.

5.3. Classifications of characteristic graphs

In the previous subsection we presented a graph, for which the following inequality is satisfied $\alpha(G\boxtimes^p) > \alpha^p(G)$. It turns out that there exist other classes of graphs, which satisfy the aforementioned inequality. What is interesting, the cycle on 5 vertices is the smallest graph, in the sense of the number of vertices, which satisfies this inequality. Generally, the independence number, the Shannon capacity and the largest number of codes in the considered model, are related to each other with the following inequality chain $\alpha(G) \leq (\alpha(G\boxtimes^p)^{1/p}) \leq C'_0(G)$, for every p and any graph G. Thus we can classify characteristic graphs by satisfying the equality $C'_0(G) = \alpha(G)$. Graphs, which satisfy this equality we call graphs of *type* I. Otherwise the graph G is called a graph of *type* II. The inequality $\alpha(G) \leq C'_0(G)$ given earlier gives us a way to characterize better the graphs of types I and II. Due to this inequality, the graph G is of type II if and only if $\Theta(G) > \alpha(G)$.

Another classification was introduced by Guo i Watanabe [GW90]. Let G be a graph. By $K(G)$ we denote the smallest positive integer k such that $C'_0(G) = (\alpha(G\boxtimes^k))^{1/k}$, if such number exists. Otherwise, $K(G) = \infty$. Thus for any graph G, if $K(G) = 1$, then the graph G is of type I; while if $K(G) > 1$, then the graph G is of type II.

Among the known graph classes, for example trees are graphs of type I. *Trees* are connected graphs without cycles. Another, wider class of graphs of type I are the so-called *perfect* graphs. To define this class of graphs we need one more concept. *The chromatic number* of a graph is the smallest number of colors needed for a proper coloring of a graph, that is, a coloring in such a way that two vertices have different colors if they are adjacent. The graph G is called a perfect graph if for any subgraph of the graph G, the independence number is equal to the chromatic number of this graph. What is interesting, perfect graphs contain trees as a subclass. Cycles on n vertices are of type I, if n is even. Otherwise they are of type II, that is if n is odd. Additionally, if the independence number of the graph G is equal to the chromatic number of the complement of G, then the graph G is of type I [S56].

5.4. Methods and results of the research

Interested in the problem, we performed some empirical study determining characteristic graphs of the problem defined in previous subsections.. We simulate a situation in which the machine scans the caption from a pack, and then tries to recognize this caption. We assume that the printouts on the packagings are of very

high quality. The registering device has a specified pixel resolution. Additionally we assume that the distance between letters is constant and the font used on the printout is monospace, that is, each letter has the same width. If the considered system was created for identifying objects, then it is difficult to imagine that the last two conditions are not satisfied. However, it is possible, but we shall not investigate this. In our research we closed letters in em squares, that is, in squares of size of the current font. Thus single characters in strings do not affect the other characters while registering the text. Thus we can focus on processing of a single character. Under the above conditions, the characteristic graph for a string of length *n* will be an extension of the characteristic graph for individual symbols using the strong product.

For simulating the process of scanning the text of high quality, we used the *GIMP* open source software. *GIMP* allows to convert images without opening the graphical user interface. Images are created and processed using scripts from the command line of the system, that is, using the so-called batch mode. Scripts are mostly written in the language Scheme, which is one of the many dialects of the language Lisp. Scheme has been designed at MIT and is standardized by IEEE [I08]. The script that we used is given below.

```
1:(define (new-text font text width height filename)
2:  (let* ((image (car (gimp-image-new width height GRAY)))
3:   (layer (car (gimp-layer-new image width height "layer1" GRAY-IMAGE 100
NORMAL-MODE))))
4:  (gimp-drawable-fill layer BG-IMAGE-FILL)
5:  (gimp-image-insert-layer image layer 0 0)
6:  (gimp-text-fontname image layer 0 0 text 0 FALSE height PIXELS font)
7:  (gimp-file-save RUN-NONINTERACTIVE image layer filename filename)
image))
```

What is interesting, in the language Scheme all data and instructions are lists. Adding two numbers 10 and 5 is noted using the prefix notation as (+ 10 5). Generally, in the language Scheme, the built-in functions and those created by the users, are usually caused in the following way: (f par_1 $par_{2\ldots}$), where f is the name of the function, while par_1 $par_{2\ldots}$ are parameters.

The first line of the above code defines the function new-text, which creates a text with given properties. In the function new-text , reading from left, font means the font, which will use the script, text means the string that is to be created, width and

height are width and height, respectively, of the font font in pixels. In our study, the last two parameters width and height are equal. At the end, in filename we specify the path and file, in which the data has to be stored. In the second line, using the function gimp-image-new we create an image of width width and height height. The last parameter specifies the type of the created image. In our case, it will be an image of type grayscale. The function returns a list with the ID of the created image, which is next assigned to the name image. In the third line we create, using the function gimp-layer-new, layer of name "layer1" and assign it to the name layer. Additionally, layer is set to the standard mode, that is to NORMAL-MODE (the last parameter), and opacity (the last but one parameter) we set to 100%. In the fourth line, the function gimp-drawable-fill fills the layer with a standard background color. The fifth line calls the function gimp-image-insert-layer and adds layer layer to the picture. The next, sixth line creates a text of given font and size height. In this case, the unit is pixel, thus the ninth parameter is PIXELS. The last, seventh line saves the image in a file that is specified in the parameter filename.

For text recognition, we used the program *tesseract*, which can be installed free of charge from a standard Linux repository. From 1985 to 1995, the program was developed by the Hewlett-Packard company. Since 2005, the program code is open and has been developed by the Google company [L]. In the program there is a function, which treats and recognizes the information in the image as a single character, which is consistent with our considerations. Additionally, it is possible to configure the program from an additional file. In the case of our investigations, the configuration file contained the following content.

```
tessedit_char_whitelist ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789
```

This content means that the result of the text recognition can be characters from a string located after the keyword tessedit_char_whitelist. So our characteristic graph is the subgraph of the characteristic graph with the vertex set equal to the set of all characters from a considered font.

For joining the results of the program written in the language Scheme and the program *tesseract* we used the language Python, which contains many interesting functions for processing files and large amounts of information.

In our research, the characteristic graph depends on the used: algorithm, font and the resolution of the device. Let us define $NC_p(A, F, R)$ as the number $\alpha(G^{\boxtimes p})$ for a given algorithm A, font F and the set of pixel resolutions R. Let T be the

algorithm applied in the program *tesseract*. The text can be scanned in different resolutions, thus the characteristic graph will contain the information on all possible errors that may appear in the resolutions of the set *R*. In our analysis, this set will consist of the natural numbers from an interval [*a*, *b*].

In Figure 1 and 2 we presented the characteristic graphs obtained by us. We did not expect such results, for example, in Figure 1 "W" may be confused with "H". The remaining results are present at our homepage.

Our research indicates that the characteristic graph for the considered problem is often a graph of type I. Moreover, in accordance with intuition, characteristic graphs for high resolutions are rare. Thus a potential algorithm can be one of the greedy algorithms. The result of such algorithm is a lower bound on $\alpha(G^{\boxtimes p})$. It is worth to note that a greedy algorithm will also find a set of distinguishable strings from the considered problem, but not necessarily the largest. One of the greedy algorithms used for estimating the size of a maximum independent set of a graph is the algorithm MIN. This algorithm is given below.

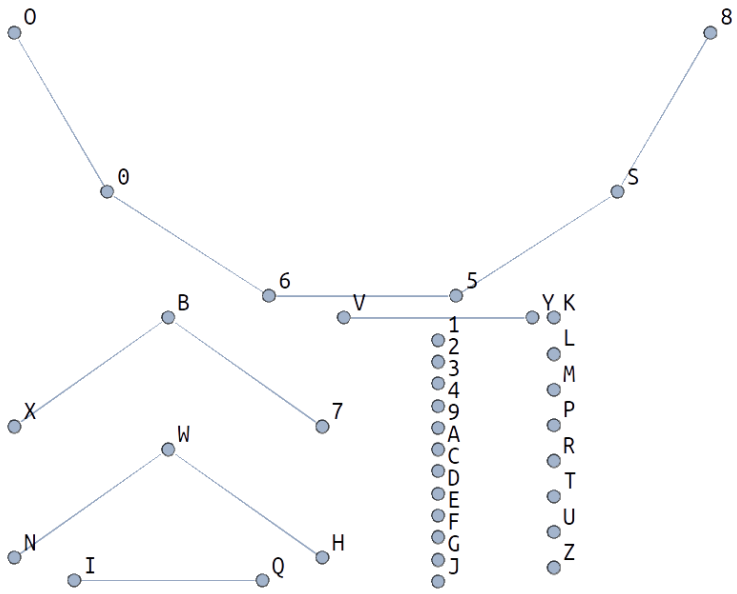

Figure 1. The characteristic graph obtained for the font F_1 = Ubuntu Mono with the resolution interval [20, 80]. The graph is of type I, as it is a tree. Since $NC_1(T, F_1, [20, 80]) = 29$, we have $NC_p(T, F_1, [20, 80]) = 29^p$. For $p = 1$ the set of distinguishable strings can be {"1", "2", "3", "4", "6", "7", "9", "A", "C", "D", "E", "F", "G", "H", "I", "J", "K", "L", "M", "N", "O", "P", "R", "S", "T", "U", "X", "Y", "Z"}

1: function MIN(G)
2: $G_1 \leftarrow G$, $j \leftarrow 1$
3: while $V(G_j)$ is not empty do
4: choose i_j from $V(G_j)$ with $d(G_j,i_j) = d_m(G_j)$
5: $G_{j+1} \leftarrow G_j - (\{i_j\} \cup N(G_j,i_j))$
6: $j \leftarrow j + 1$
7: $k \leftarrow j - 1$
8: return k

The input of the algorithm is the graph G. In the next iterations, we choose a vertex i_j of the smallest degree in the graph G_j, that is, of degree $d_m(G_j,i_j)$. Next, we remove from the graph G_j the vertices adjacent with i_j, that is $N(G_j,i_j)$ and the vertex i_j, and assign the resulting graph to G_{j+1}. The algorithm executes loops as long as the set $V(G_j)$is not empty.
Let G be a graph. Let I_1 be any independent set of the graph G and $I_p = I_1 \times I_1 \times \ldots \times I_1$, where I_1 occurs p times. Then I_p is also an independent set of the graph $G^{\boxtimes p}$ and $|I_p| = |I_1|^p$. It turns out that in the majority of cases, in order to estimate $\alpha(G^{\boxtimes p})$, it is better to run the greedy algorithm MIN for the graph G, and next estimate $\alpha(G^{\boxtimes p})$ using $|I_1|^p$, instead of calling MIN for the graph $G^{\boxtimes p}$.

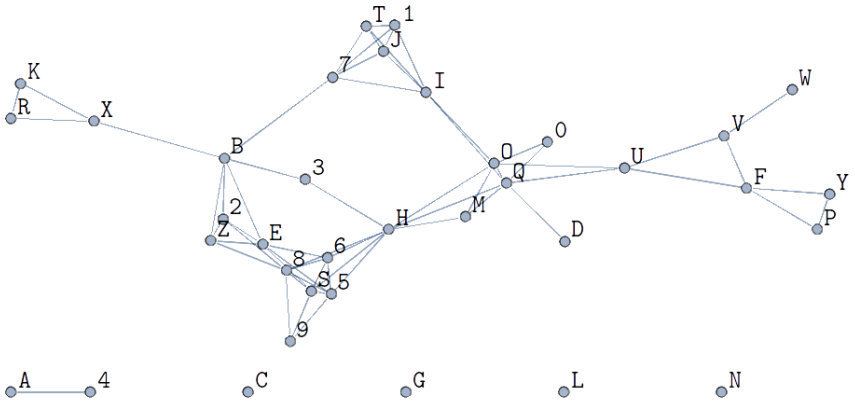

Figure 2. The characteristic graph obtained for the font F_2 = LM Mono Caps with the resolution interval [10, 60]. We have $NC_1(T, F_1, [10, 60]) = 17$ and for $p = 1$ the set of distinguishable strings can be {"0", "1", "2", "3", "4", "6", "9", "C", "D", "G", "K", "L", "M", "N", "P", "U", "W"}

5.5. Other applications of the formalism of Shannon

In this subsection we present two other issues, where the methods of solving problems related to the Shannon capacity have been applied. The formalism of Shannon applied in the work [S56] was used for example by Lin and Chang [LC01] in the article concerning digital watermarks, that is, a technology for hiding information in an object, possibly a picture, to identify for example the owner of the object. More information on this topic can be found also in the Ph.D. Thesis of Lin [L10] and in the book [L04], the editor of which is Lu.

One of the most important applications of the formalism and methods used in the considered problem is the function introduced by Lovász [L79], which for the majority of small graphs exactly determines the size of the maximum independent set, and in the remaining cases it is the best upper bound of this value. Hence, it is also the best upper estimate for the problem of finding the size of the largest clique in a graph, since this problem is dual to the problem of a maximum independent set, that is, for a given graph, the size of a maximum independent set is equal to the size of the largest clique belonging to the complement of the graph. Both problems have countless applications.

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Chapter 6

Facial data registration facility for biometric protection of electronic documents

In modern world, information is crucial, and its leakage may lead to serious losses. Documents as the main medium of information must be therefore highly protected. Nowadays, the most common way of protecting data is using passwords, however it seems inconvenient to type complex passwords, when it is needed many times a day. For that reason a significant research has been conducted on biometric authentication as an alternative to passwords. While there is a wide selection of device biometric protection methods and tools (like face logon plugins to Windows [KL]), lightweight biometric encryption of digital documents has not been deeply investigated yet.

6.1. Introduction

Biometric protection of documents exchanged in virtual organizations is one of novel features of the proactive document architecture developed in the project MENAID - Methods and tools for next generation document engineering [W13]. Experimental system called For Your Eyes Only (FYEO) relieves members of the organization of inventing and memorizing complex and secure passwords. Strong passwords are generated automatically with minimal effort of the document's user by using his/her facial biometric data.

User registration point is a key component of any virtual organization willing to use biometrically protected electronic documents. Authors of this chapter are responsible for that feature in the FYEO system. This chapter describes the work on biometric data acquisition module, subsequent sections discuss various aspects of this task: registration point in FYEO context, challenges associated with biometric data acquisition, developed architecture with the used technologies and the future work in this area.

6.2. Registration point in the FYEO context

A user definition in the *For Your Eyes Only* system is comprised of two components: user information and biometric facial data. While user information is a typical record with text fields identifying the given person, biometric data takes the form of a special file. This so called *DEF file* contains a compound vector of

unique face features and plays a key role in FYEO encryption/decryption process [SSW13].

The user's face is first scanned by a camera at the registration point of the organization, where the DEF file is generated. A simple registration point is a dedicated workstation with required FYEO software and a camera. After taking photos of the user's face, they are processed locally, so there is no risk of their leakage, but on the other hand, a user has to arrive in person at such point. Alternatively, a more complex registration point is a remote service which takes pictures with the camera embedded in the user's device and sends them to a server for processing.

In any case, the obtained DEF file is used as the source for generating personal passwords used to encrypt documents. The encrypted document is subsequently sent via an e-mail to the registered member along with his/her facial data file. When attempting to open the received document, its embedded biometric service takes the recipient’s photo, verifies his/her identity against the received facial data file, and either rejects the user or generates a password opening a document based on the positively verified facial data.

It is worth noting that existing and well known encryption mechanisms (e.g. AES or DES) are employed by the FYEO system. A strong biometric password is generated in a convenient way for every protected document, but no special cipher is required. The generated textual password is passed down to the encryption mechanism embedded in the chosen document format, as if it was a typical password. What is more, the above biometric protection mechanism is as strong as possible, i.e., depends only on the strength of specific encryption algorithms used by available tools intended for the particular document format [RND].

The FYEO system exploits existing document file formats. Currently documents' content encryption is supported in two file formats: PDF and ZIP. PDF architecture has one notable advantage comparing to ZIP, which is document content encryption while leaving the metadata unencrypted [PDF]. In contrast to PDF, ZIP file can only be encrypted as a whole, so it is impossible to get any specific information about the document prior to its decryption [ZIP].

6.3. Challenges

Realization of the project had to meet several important challenges:

- **Interoperability** - the first assumption was that facial data registration facility will be used in many various situations. It was meaningful, to assure that all of the users are able to use this facility any time they need, and from any device they can currently access. Therefore, the application had to support a variety of platforms - from smartphones to desktop computers.
- **Privacy** - the registration point facility is operating on a very sensitive personal data, which are photographs of the user. Leakage of the photographs could be exploited by outsiders to obtain access to the encrypted document. It also infringes the privacy and the security of the user. For this reason privacy was a crucial issue.
- **Dependability** - the registration point facility would not be useful, if it generated an incorrect biometric definition of the user's face (DEF file). Hence, after submission of the photographs, they had to be verified against the required criteria. Pictures of poor quality, or pictures that do not represent user's face had to be rejected and recaptured again. It is also worth mentioning that people's face is changing in a longer time. Therefore, user will have to renew the password periodically. It not only decreases the chance of authentication problems, but also improves security - the practice of periodical password refresh is a very common method, used to reduce probability that intruder breaks it.
- **User experience** - one of the key concepts behind FYEO system is to simplify the process of user authentication and thus improve the user experience. Thereby the module needed to provide the same ease for user registration. Registration had to be fast and require minimal intervention from the user's side.

All of the challenges have been addressed during implementation by designing a proper system architecture and usage of well-suited technologies.

6.4. Implementation

6.4.1. Architecture overview

According to Fig. 1, in the module's architecture we can distinct three parts. The point of interaction between the user and the system is a Web or mobile client. The

Web client, which is already implemented, asserts very high interoperability. The registration facility is available for every device that supports the most popular internet browsers. Through the client application, users fill in simple registration form where they give only necessary data like login and e-mail. After completion of the form, they are prompted to take a series of photographs, and choose which of the pictures should be used to generate biometric face definition. At this stage photographs are also verified against the required criteria. Only photographs that pass verification can be used in the DEF file generation. The process of generation is conducted on the server side. Photographs are transferred to the server via a secure channel, using SSL (Secure Socket Layer) protocol.

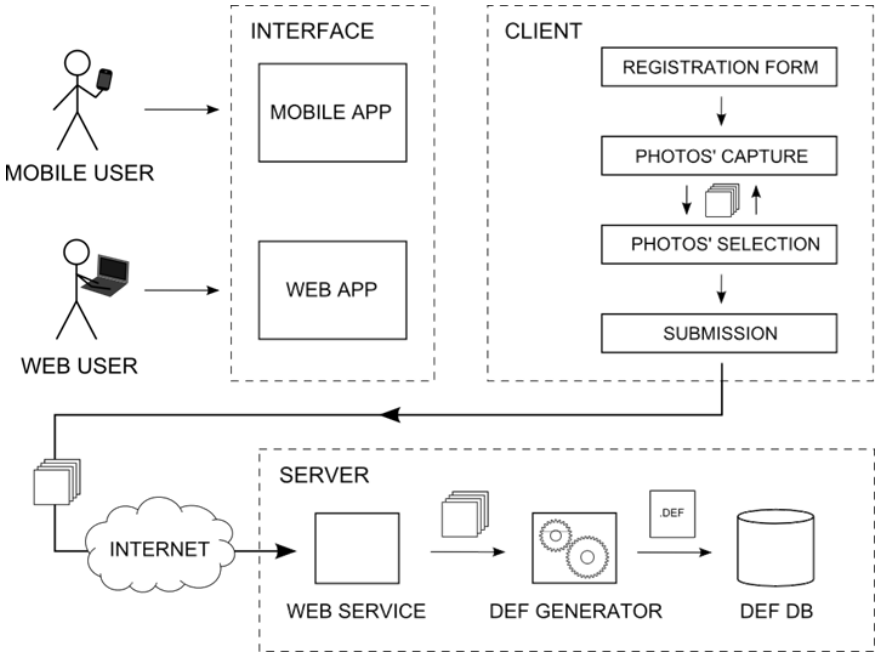

Figure 1. Rich picture of the registration facility.

Submitted pictures are processed by a set of classificators included in a C++ library and the DEF file is generated. The library was developed as a part of the SART2 project. It generates results as a combined output from several different classificators, which are trained on real photographs presenting human faces [SP11]. Finally, users' data provided in the form along with the definition of their faces, are stored in a database on the server.

Photographs of the user are not kept in the database. They are removed immediately after the DEF file is generated to assure the required level of privacy and security. There is also an intensive development of generating DEF directly on the user's device. Such a solution would eliminate potential vulnerability for attacks during transmission of the photographs through the Internet.

6.4.2. Web client

In the Fig. 2 the page for collecting user's personal information is shown. It contains a classic form. There are inputs for the first and the last names, e-mail address and affiliation.

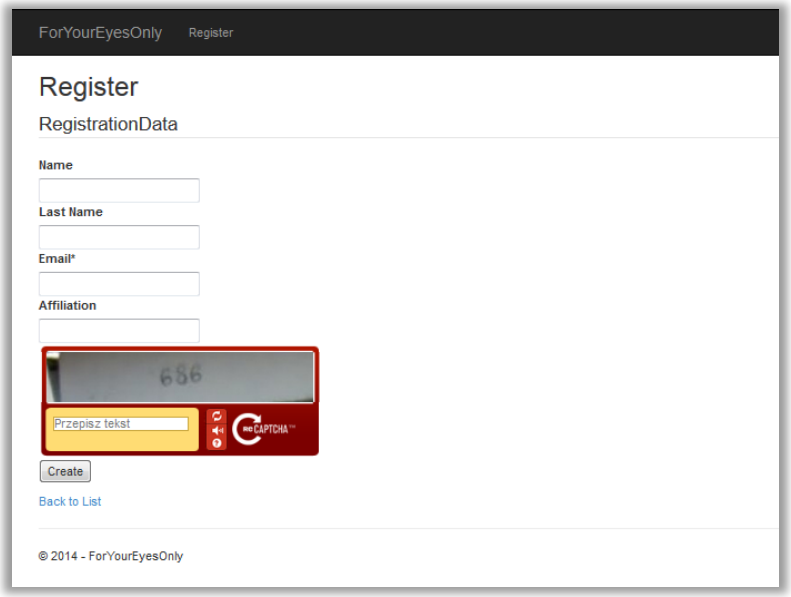

Figure 2. Web client - registration form.

The form is secured by both client and server side validation. It also uses CAPTCHA mechanism to prevent automated clients from registering.
After filling in the form, users are redirected to the main page, which is presented in Fig. 3. Due to the live camera preview, they can easily verify and adjust their position relative to the camera. They have to take about ten photographs. It can be done in two manners - users can either click snap button for each photo or use the photo series mode. If the user is not satisfied with any particular photograph, it can

be removed. Next step is uploading the captured pictures to the server, where they are verified and stored. Any picture that is rejected by the server (if algorithm did not recognize any face on it for example), should be replaced with a new one. When all the photographs are successfully uploaded, user has to wait until the process of generating DEF file is completed.

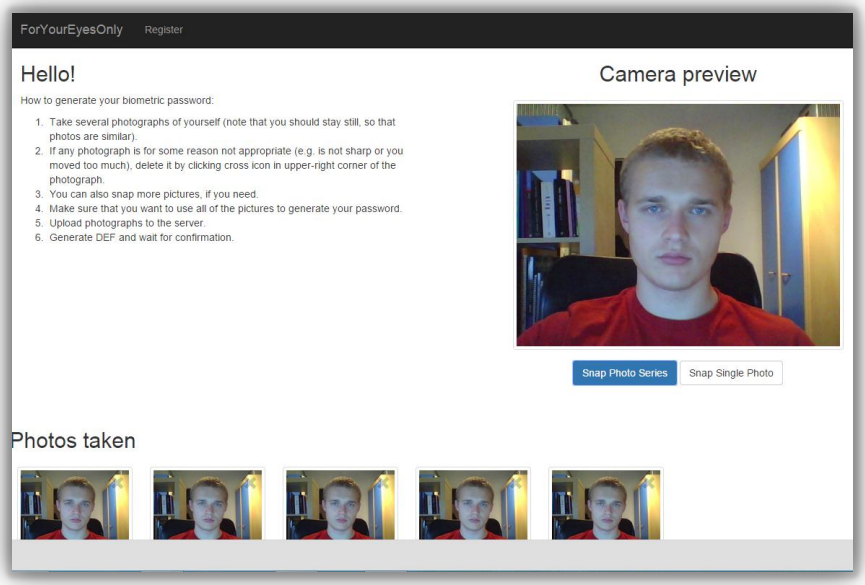

Figure 3. Web client - main page.

6.4.3. Technologies used

ASP.NET developed by Microsoft has been chosen as the server side framework. Server functionality has been split into two applications. The first one is a web service created using ASP.NET WebApi extension, called by all clients.

The second application is a Web client based on the ASP.NET MVC extension. Web client uses HTML5 API for accessing the camera, which is supported by the majority of modern browsers today. To provide a more flexible user experience, the main page of the Web client has been designed as a single page application. Thus, it required a rich client side that has been implemented in JavaScript. Its implementation is based on MVVM architectural pattern [JG05], which has been applied with use of KnockoutJs framework [KO].

6.5. Conclusion

Primary objectives of the *MENAID* project have been development of the novel electronic document architectures, which are mobile, executable, intelligent and forward compatible [W13]. *For Your Eyes Only* documents meet these objectives, as they migrate between users, execute their embedded functionality and use AI algorithms for self-protection – all this in full compatibility with the existing document formats. The FYEO system is complex, but thanks to its modular design, it can be enriched by adding new modules or replacing particular components with their enhanced versions.

The registration point created by the authors of this chapter addresses all the most important challenges associated with biometric data acquisition: interoperability, privacy, dependability, and user experience. Not only has it been achieved by usage of the proper technologies, but also due to design of well-considered system architecture. By taking the form of a remote web application, the registration point enables worldwide cooperation within a virtual organization. It is a step towards replacing the traditional security model based on textual passwords with one based on biometric face verification. This new model of protecting electronic documents seems to be not only secure, but also more convenient for its users.

Acknowledgement

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Chapter 7

The application of eye tracking in business

Eye tracking is a method of study allowing for the verification of how humans perceive objects in front of them (e.g. Internet websites on the computer screen). This method consists in tracking the movement of eyeballs with the help of a specially designed video camera which is capable of registering even the most minute eye movements. Thanks to this method we can learn what people look at, which elements are perceived by them and which are omitted. It allows to check whether a particular graphic design, e.g. for an Internet website or an advertisement, meets its marketing objectives – i.e. whether recipients see those elements of the message which are crucial to the seller [W13].

7.1. Introduction

This technology is especially useful when studying the behaviours of the clients of Internet shops. Thanks to eye tracking, website designers have the possibility to understand how consumers see and read websites created by them [NP10]. They may measure what way the gaze of potential clients crosses in order to accomplish the intended tasks, on which parts of the website their gaze stays longer, how they react to advertising (whether they look at it at all), whether the menu navigation is clear enough for the first-time visitors, how users react to the contents of both texts and images, as well as films and flash clips.

7.2. The work of eye tracker

The mode of action of an eye tracker is based on the observation of eye movements with the help of an Internet camera or specialist light emitting diodes placed in the corners of a screen. The camera detects the placement of eyeballs (or pupils, to be more precise), which are lit with infrared light invisible to the naked eye (fig. 1). Infrared is reflected in the eyes and creates reflections, which are known in physics as ‘Purkinje images’. Those reflections are well-visible reflexes in pupils (fig. 2). Those reflections may be tracked with a camera. By observing the reflection of the diodes on the eye, one may identify the place the person is looking at.

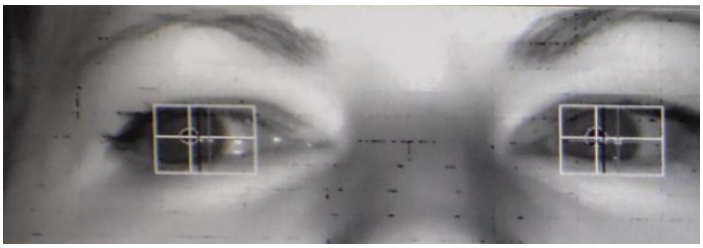


Figure 1. Pupil movement tracking by an eye tracker made by SensoMotoric Instruments (SMI)

Source: author's own materials.

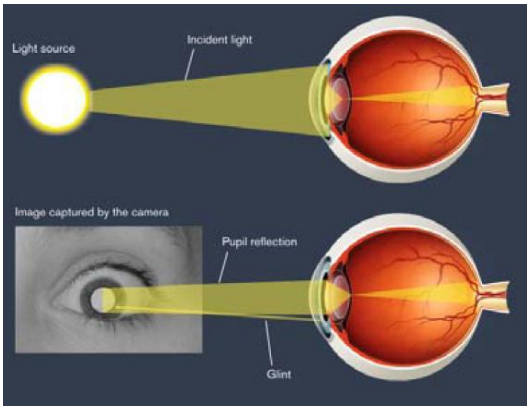


Figure 2. How a reflex in the pupil is created

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

Both stationary eye trackers (integrated with a computer screen) and mobile devices (usually to be put on the head) are available on the market (fig. 3).
Stationary eye tracker does not differ in appearance from an ordinary monitor. During the test there is no need to connect the respondent to any external device. Hence the test is entirely non-invasive. During the test the respondent simply sits in front of the monitor and watches projected images. In the casing of the LCD screen there is a hidden miniature video camera which records images for both eyes. The control programme processes those images and in real time provides data on the current line of sight direction, i.e. which point of the screen is looked at by the respondent. The measuring process is done "in the background" and therefore does not limit in any way the natural behaviour of the respondents during their work

with any utility programme, particularly an Internet browsers and Web applications. The measurement provides precise information about which points of the screen are looked at by the respondent. The position of the eye is measured 60 times a second and hence one is able to record even really quick glances and reading process with high accuracy. The accuracy of the measurement is more than 1 cm on a 19-inch screen for a typical distance range for working with a screen, i.e. ca. 50-70 cm. The system used by us is dedicated for Human-Computer Interactions (HCI) studies.

a) b)

Figure 3. An example of
a) a stationary eye tracker - Tobii TX300, b) a mobile eye tracker - Tobii Glasses

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o

A mobile eye tracker, on the other hand, allows the respondent to enjoy full freedom of movement in their natural environment, which allows the researcher to gather data regarding what has drawn the attention of clients in shops or whether they have noticed prominently displayed elements of interior design (fig. 4). It may also be used for the optimisation of the display of information and marketing elements. Eye movements of a respondent are recorded by the device and subsequently, thanks to using radio communication with the workstation, are sent to the workstation where they are digitally processed, analyzed and interpreted.

Figure 4. The study of shelf display with the use of a mobile eye tracker Tobii Glasses

Source: http://www.tobii.com/en/about/news-and-events/press-room/#/images/tobii-glasses-in-package-design-shopper-research-68340

7.3. Calibration of an eye tracker

Before eye tracking is recorded, each respondent undergoes a calibration procedure [D07]. During this procedure an eye tracker measures the characteristics of respondent's eye and uses them, together with an internal physiological 3D eye model, to calculate gazing data. The 3D model gathers data on the shape, refraction of light and the properties of refraction for different parts of the eye (e.g. cornea, the placement of the fovea, etc.). This is followed by sampling in points of calibration, which appear on the screen (fig. 5). On this basis samples for a chosen amount of points are gathered. The results are then integrated with the model (there is a moment of learning the model).

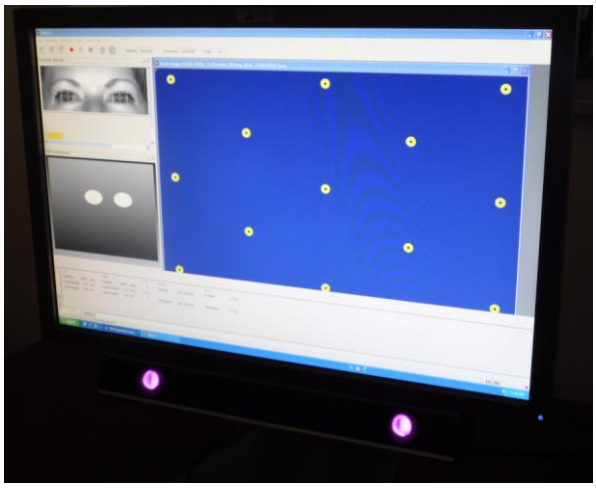


Figure 5. Calibration of a SensoMotoric Instruments (SMI) eye tracker

Source: author's own materials.

Once the calibration procedure is finished, its quality is illustrated e.g. by red and green circles (fig. 6), with red circles indicating where the calibration is not correct and the green ones where it is proper. Additionally, the accuracy ratio for the left and the right eye is calculated. By properly executed calibration this ratio should not be higher than 1. If it should exceed 1, the calibration procedure should be conducted again.

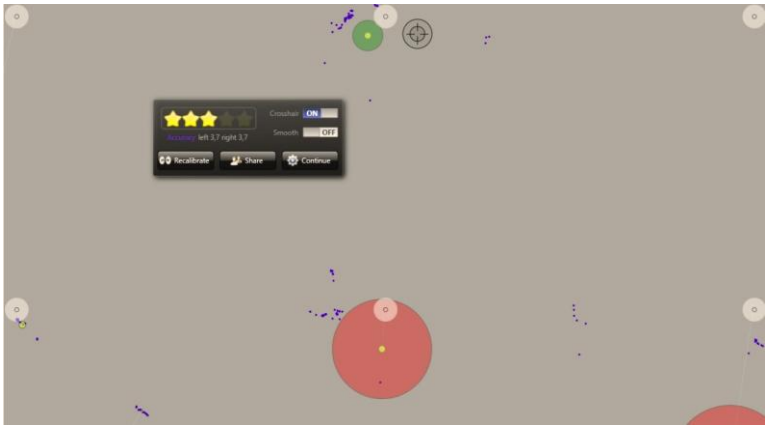


Figure 6. Calibration window in the ITU Gazer Tracker programme

Source: author's own materials.

7.4. The methods of analyzing and presenting the results

The majority of eye tracking data is analysed in the context of performing specific tasks, e.g. reading, searching information. The interpretation is done on the basis of the registered:

- fixations – the time the eye is focused on one element of the image,
- saccades – moving the eye from one focus point to another,
- residence time in a particular area of interest, calculated from the moment of making the decision to move to that are,
- mean time and total time dedicated to looking at particular elements of the test object,
- number of revisits – returns to a certain element (e.g. company logo, slogan, studied product),
- individual elements of an image depending on the type of material tested.

Tables 1 and 2 show various methods of presenting data obtained in eye tracking studies.

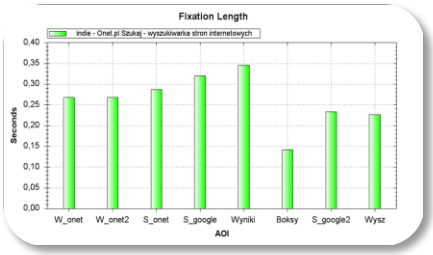
Table 1. Methods of presenting eye tracking test results – part I.

	Scanning path Presents the sequence of perceiving individual areas. It allows to specify whether the elements crucial for the Client are perceived first. It helps to identify elements distracting from the main contents.

	Heat maps Summary results of attention focus of a particular group of respondents. It allows to determine which elements of a service/advertisement drew the attention to the greatest extent and which were ignored.
	Blind zone maps More graphic presentation of a classic heat map. Highlights clearly for the Client which elements of a service/advertisement were noticed by a user.

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

Table 2. Methods of presenting eye tracking test results – part II.

 	Statistics Averaged or summed up data concerning chosen issues, e.g. the duration of fixation on particular areas of interest, mean time necessary to find certain information, attention distribution according to respondents' sex, age, proficiency in navigation, etc. Separate areas with percentage record of attention distribution shown for example in the form of semi-transparent layers superimposed on the advertisement, containing the percentage description of how particular elements attracted the attention. Various statistic may be gathered for such areas.
	Videos of conducted studies Precise record of what the respondents did during the study. Where they looked, for how long and in what sequence, which contents escaped their attention. The film may be supplemented with a preview form a camera recording respondents' reactions. They allow to analyse user's exploration path of the material.

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

7.5. The uses of eye tracking

Taking into account the fact that looking and cognitive processes connected therewith occur almost all the time and everywhere, eye tracking studies are not only used to study how useful particular applications and Internet services are. Modern eye trackers are becoming increasingly common in studies concerning many fields of life, starting at navigating in a real-life shops and looking at shelves, perceiving the urban space, through watching outdoor advertisements and television commercial, driving a car, up to sports games [WP06].

The analysis of human perception provides us with information not only to study where the gaze is directed but it also constitutes a basis for the studies of problem solving, reasoning, attention or mental images. Eye tracking allows to understand many aspects of human cognition and behaviour, and the range of its applications is still growing.

The main measures used in eye tracking are fixations, i.e. focusing the eye on one element, and saccades, which are fast movements of an eye, occurring in between fixations. One should, however, remember that eye tracking studies do not provide clear answers as to whether a user understands the perceived contents. Only data on how it is processed is obtained and such data may be variously interpreted.

The future of eye tracking are not only the studies of the Internet, but first and foremost other visual media, such as television, games, virtual environment and urban space. This will not only extend the range of studies, but also the knowledge about psychological bases of gazing, attention and remembering. This will be affected by technological development and more detailed measurements with ever less invasive apparatuses connected therewith. In Polish market analyses of such areas as urban space or television with the use of eye tracking are still rare. Current results of an eye tracking study may provide us with answers to the following questions:

- What attracts client's attention and what remains unnoticed?
- Is information included in the tested materials visible?
- Are the crucial elements of press and television advertisements noticed?
- Are the logo and the brand placed in the best possible place?
- Is the brand included in product placement appropriately located?
- Are Internet sites, instruction manuals or forms created correctly and clearly?
- Are there any distracters in the studied material?
- Is the product correctly displayed in the point of sale?

7.6. The areas of the use of eye tracking

Eye tracking in usability testing

This area is of key importance in studying Internet sites and applications. Not only for marketing purposes but also in studying interactions of the process with the application. Thanks to this we are able to check:

- the trajectory of the eyeball movement and the time of focus on particular objects,
- in what sequence objects attract client's attention ,
- distracting elements,
- frequently viewed elements,
- correct or incorrect display of modules on the website, by the sequence the objects are scanned.

The use of eye tracking to study ergonomics

From the point of view of a client, ergonomics is of key importance when choosing a product. Here it is measured how easy and intuitive a product is in use. Eye tracking studies of ergonomics are used in testing mobile phones, panels, cockpits, audio/video devices, household appliances and even working posts. Thanks to this study we can check:

- the clarity of the elements,
- what distracted the respondents,
- which elements were not found and why,
- whether their use and behaviour was predictable,
- whether the elements were in places the respondent expected them to be.

The use of eye tracking in psychology

Eye tracking studies increasingly often provide new possibilities in many areas of psychology. We owe it to the technological development and increased availability of equipment as well as the increase in analytical possibilities. Eye tracking may be used in:

- *cognitive psychology and cognitive science* – eye tracking studies of the perception of visual stimuli, relations between the form of information and the way it is perceived, the behaviour of people while driving vehicles and human-computer interactions;
- *developmental psychology* – eye tracking studies of the development of eye-hand coordination, the development of attention allocation skills, relations

between motion control system and text comprehension and the studies of autism;

- *experimental psychology* – eye tracking studies of face perception and recognition, visual perception of scenes and images and the differences in using visual and spatial functions in healthy people and people with damage to the nervous system;
- *psycholinguistics and reading* – eye tracking studies of recognising reading difficulties, training programmes supporting reading skills and the correlation between visual perception and reading proficiency;
- *neuropsychology and mental health disorders* – eye tracking studies of the analysis of the strategy of watching scenes and images by healthy and diseased people, correlation between EEG images and eye movements and the exploration of seeing mechanisms;
- *ophthalmology* – eye tracking studies of the properties of rapid eye movements, diagnostics of disorders of muscles moving the eyeball and the assessment of the effect of surgical and conservative treatment of, for example, strabismus for patient's eye and movement activity.

The use of eye tracking in advertising

The study of advertising creation aims at checking what the client really sees and what is totally ignored. Thanks to this we have the possibility to optimise the advertising message and choose the best design option. Eye tracking study allows to determine which elements were viewed most often and longest. The first seconds of client's contact with the advertisement are essential. Eye tracking shows which elements attracted the attention and which remained unseen. Therefore we have the full and detailed picture of the effectiveness of each advertisement. With the use of eye tracking we may study:

- press advertisements,
- video commercials,
- internet advertisements,
- outdoor advertisements,
- e-mailing.
- The use of eye tracking in studying the shelves in shops

Eye tracking has its use in modern commerce, where current methods have not provided satisfactory results. It concerns both macro- and micro-level navigation. Macro-level navigation refers to the layout of product categories in the entire area

of a shop or one shelf. It is connected with the communication of categories and sales sections. Eye tracking studies aim at suggesting appropriate layout of products in order for clients to freely move around the shop and at the same time to have all the informative elements within the reach of their sight. Micro-level navigation consists in building planograms, i.e. optimum layout of particular products on a shelf. This aims at adapting sale space in order for it to be as efficient as possible. Aside from sale in its value and quantitative approach, one should also take into consideration clients' needs, i.e. placing product on shelves according to their needs. Micro-level navigation also deals with the clarity of price and product labels.

Eye tracking is used during qualitative studies and supplements the process of studying shelves. In this part of the study various shelf arrangements, advertising materials, price labels, wobblers, etc., are tested. The behaviours of a respondents are examined with the use of an eye tracker in conditions which are as natural as possible.

Thanks to eye tracking systems our environments becomes increasingly clear, i.e. we will easily find our way to the underground station, cash point, or a particular shop in a shopping centre. Eye tracking is also used in assessing the evacuation and warning signs.

7.7. The examples of eye tracking use

Example 1

The study uses a stationary eye tracker X2. Respondents' task was to look at packages of mint chewing gums by various producers. The aim of the study was to check to what extent particular graphic elements attract attention. Figure 7 shows summary results of the attention focus of a group of respondents in the form of a heat map.

The heat map allows us to conclude that:

- central location and contrasting colours of the logo on the package of the "Trident White" gums strongly attracted respondents' attention,
- vertical lettering on the package of the "Dentyne Ice" chewing gums caused the respondents' attention to be spread all over the package,
- horizontally placed logo on the package of "Trident White" gums concentrated the attention in one place.[1]

[1] *Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.*

Figure 7. Summary results of the attention focus

Source: „Eyetracking. Solutions and Research", material provided by Eyetracking Sp. z o.o.

Example 2

In a study with the use of a stationary eye tracker the respondents were asked to perform two tasks. The first one consisted in finding a chosen product, and the second one – subscribing to a newsletter. The commands were formulated in a general way. The eye tracking study was done on the basis of shop masks of an Internet shop in food industry (data on the basis of study report *Eye tracking studies of shop masks of Home.pl, IAI-Shop.com and Sote.pl* [*Badania eyetrackingowe masek sklepów Home.pl, IAI-Shop.com i Sote.pl*], http://blog.sote.pl/wp-content/uploads/badanie-ideacto-usability-sklepow.pdf). The results, shown in the form of a heat map, showed those elements of shop's website which require improvement and proven solutions (fig. 8).

The study showed that:

- the placement of the searching option was very intuitive – respondents did not have to waste time to find it,
- simple and clear layout of the page resulted in the fact that respondents had no difficulties in navigating the shop and finding options they needed (e.g. newsletter),
- the ordering process was intuitive and posed no difficulties for respondents,

- search option that did not search for alternative names of products impeded the completion of the task,
- incomprehensible categorising impeded finding products,
- they only action buttons on the product lists were the "add to cart" buttons – there was no action to go to the product card (one could go to the product card after clicking the picture),
- messages on the page were visually imperceptible, i.e. could not be distinguished from the rest of the website and therefore did not attract respondents' attention,
- no information on the measuring unit caused confusion, as respondents did not know whether they order products per item or per kilogram.

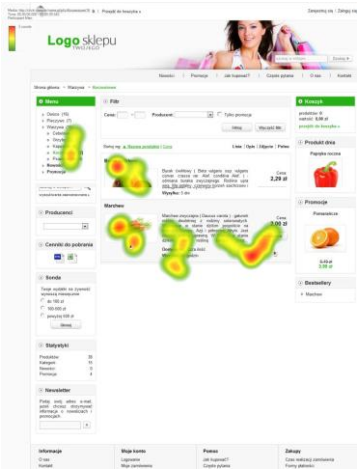


Figure 8. Heat map obtained during the analysis of an Internet grocery shop.

Source: http://blog.sote.pl/wp-content/uploads/badanie-ideacto-usability-sklepow.pdf

7.8. Conclusion

Eye tracking studies may provide many important conclusions about studied products. It is possible, for example, to offer a few designs of a particular website or application and to check in which case respondents do best. One may also check whether what people say about a product is confirmed by what they do. One should remember that study methods such as questionnaires or IDIs (In-Depth Interviews) can be purposefully falsified by respondents whereas their gaze cannot be that easily manipulated.

Eye tracking also provides answers to questions on whether respondents saw the elements key to the object of the study (logo, the "buy" button, etc.), where they expected to see particular contents, which contents were read. One may achieve really good results when combining eye tracking studies with usability tests. Thanks to this combination one may obtain information as to why people had difficulties in performing their tasks, which may not always be obtained during a regular conversation about the task. Eye tracking studies have also shed some light on the universal website designing. They helped to detect the so-called banner blindness, which shows that banner advertisements are completely ignored by respondents' gaze.

Since human sight is the most complex and the most significant way of perceiving the world by people, an eye tracker provides us with information that is impossible to obtain during any other study. It has been tested that human gaze follows the attention. This statement is the main assumption confirming the significance of eye tracking studies. There are, however, examples proving that this statement is not reversible, i.e. human attention does not follow the gaze. One of them is the so-called Ketchup Bottle Problem. It consists in the fact that people see certain elements – which is proved by eye tracking tests – but when asked about this element, they do not realise that it was displayed. This fact, hindering the interpretation of websites or applications tests, is a part of evidence that an eye tracker may be used for research for scientific purposes.

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http://blog.sote.pl/wp-content/uploads/badanie-ideacto-usability-sklepow.pdf

Chapter 8

Some comparisons between software used for EEG signals analysis

Electroencephalogram (EEG) is defined as electrical activity of an alternating type recorded from the scalp surface after being picked up by metal electrodes and conductive media [NF93]. There are many devices used for recording brain signals, each device has a special purpose for various uses, but all of them are involved in acquiring signals generated by the mind activity. Most of these devices use software from its manufacturer, all of them save the data recoded into files on the computer that is connected with the device. Usually this software has a possibility to export data into external files, the format of the file depends on supported types of the software accompanying the hardware device, also all other functions in the software. Modern medicine applies a variety of scientific research areas for imaging techniques of the human body. The group of electrobiological measurements comprises of items such as electrocardiography (ECG, heart), electromyography (EMG, muscular contractions), electroencephalography (EEG, brain), electrooptigraphy (EOG, eye dipole field) and galvanic skin response (GSR, brain). Imaging techniques based on different physical principles include computer tomography, magnetic resonance imaging (MRI) and functional MRI (fMRI)[TE02].

8.1. Introduction

This chapter is looking for knowledge about different characteristics of the tools used to analyze brain signals not only for medical measurement but also in many other research areas and aims to present and explain major steps that need to be taken for the analysis and filtering of brain signals in various software concerning this area. And we will compare the features between some of popular software such as AcqKnowledge, and EEGLAB (used for example in [VM14] we observed the mechanism of EEG signal processing in several ways, therefore, we will demonstrate major steps in separated forms that are concerned with this subject from data acquisition to the methods of data visualization, we will also explain data filtering and artifact removing to show differences between used software and tools.

8.2. Methodology of comparison

This study attempts to show how to achieve optimal transaction for the signals by the use of various software tools, because it might be demanded to build scripts with hundreds of lines of code for doing one of the operations that exists in another software with many option properties, it is going to investigate the time and knowledge needed for using these software. There are many common processing ways to execute signal analysis ([NE04], [BN08]), but the steps that should be taken into consideration for pre-processing are: loading the data, data filtering such as finite impulse response (FIR) or infinite impulse response (IIR), artifact removal using independent component analysis (ICA) or any other ways and demonstrating ways of data displaying such as waveforms, 2D and 3D visualization. There are also various methods of data acquisition and there are many algorithms for signal classification [BN04]. Here we will explain these steps and their execution in more common tools such as AcqKnowledge software and EEGLAB.

8.3. File format and data types supported

Dealing with different types of file formats is important in order to increase the possibility of program operations analysis, to load and import data recorded by different types of devices. By using AcqKnowledge software you could load such types as:

- graph – the default file format (*.acq) is referred to as "AcqKnowledge" files,
- text – text files are a convenient way of transferring information between applications,
- MAT MATLAB format – AcqKnowledge can open files created as a MATLAB work space,
- WAV – wav files containing 60 channels or less can be imported,
- EDF – it can open files with .eeg and .edf extensions saved in European Data Format (EDF).

You could also load data from other formats such as: Advance Averaging Experiment (*.aae, *.avg), Batch Acquisition (*.bcq) and Igor Pro Experiment (*.pxp). The later types, however, are not commonly used recently.

Almost the same types are possible to load using EEGLAB. There are however some other supported formats such as:

- Matlab array – a 2-D Matlab array 'eegdata' containing simulated EEG data in which rows are channels and columns are data points,
- Biosemi .BDF files – 24-bit data format, BDF (Biosemi Data Format),
- Snapmaster .SMA files and ERPSS .RAW or .RDF data files,
- Brain Vision Analyser Matlab files.

In EEGLAB you could extend the possibilities of loading file formats by downloading specific scripts from The Swartz Centre for Computational Neuroscience (SCCN) – web site that was constructed for such lab tools[1].

8.4. Data visualization and displaying signals

Row data recorded by EEG system is expressed as a time series. This representation of data is well suited to a variety of processing methods, as well as to spectral decomposition methods which play an important role in the analysis of EEG signals. Many different techniques have been developed for visualizing time series data. Aigner et al. for example present a survey covering visualization methods spanning a number of temporally sensitive datasets [AM07]. One of the main goals of visualizing time series data is to extract patterns or cycles within the ensemble for organizing collections of time series to visually detect patterns in them. Similarly, another method used multiple dot plots to discover patterns in a spread sheet like array [AN11].

AcqKnowledge displays the entire waveform (in terms of its duration), The Auto scale horizontal command fits the entire data file into the window, regardless of the total length of the acquisition. The Initial time offset box lets you jump to a different point in the time display. Changing the value in this box allows you to display data beginning at a certain point in the record. For instance, if you want to see the data at the beginning of this record, you would write in text box to display data with an initial offset of 0 seconds, which would result in the following: As you can tell from the time scale, the first data displayed on the left edge of the screen was collected at the beginning of the acquisition. Also, the scroll box has moved to the left, indicating that the data on the screen represents data collected earlier in the record. If you click in the horizontal scale area again, the same dialog will appear, and this time the value in the start box should have changed to reflect the new section of data being displayed on the screen. After executing any operation, visualization signals are displayed immediately when processing is completed.

[1] http://sccn.ucsd.edu/

On the other hand by using EEGLAB scrolling through the data of the current dataset, you may note that the sample data file contains continuous EEG data. To reduce download time, this pseudo-continuous EEG dataset was actually constructed by concatenating separate data epochs. To the right of the plot window there is the vertical scale value (unit, i.e. microvolts), which indicates the height of the given vertical scale bar. In this case, that value is 80 (microvolts). The same value is also shown in the lower right-hand edit box, where we can change it.

To plot channel spectra and maps in EEGLAB, plot all channels as a continues signal in time domain with possibility of the plot window as a vertical scale value (unit, i.e. microvolts), which indicates the height of the given vertical scale bar. To change the scale, edit text box value either by repeatedly clicking on the "-" button or by editing the text value from the keyboard to update the scrolling window. You could scroll the data or jump to specific time range and adjust setting for how many channels to view in on one window. Figure 1 displays 2D maps containing seven channels recorded for ten seconds during watching a movie clip.

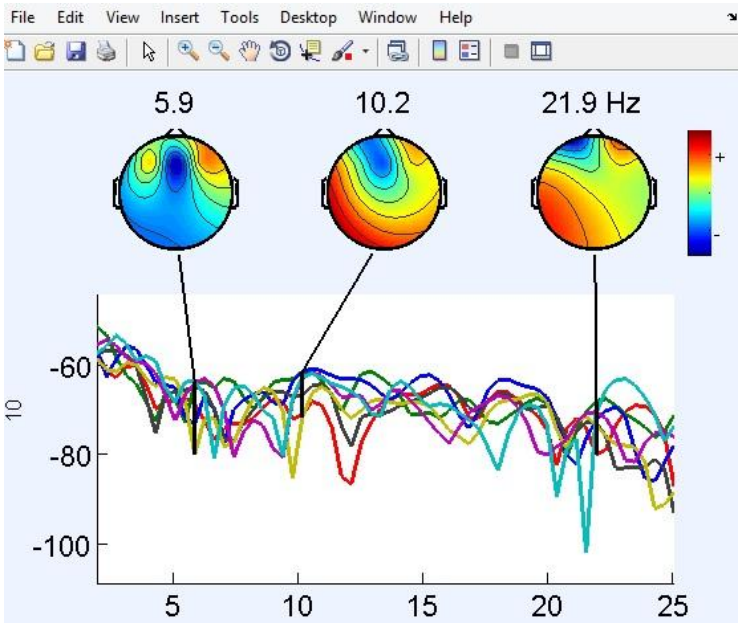

Figure 1. Displaying channels and spectral maps (EEGLAB).

To plot the channel spectra and associated topographical maps, epoch time range for analysis, present data for sample for 1 to 100 and which frequency to plot as scalp maps in Hz specifying plotting frequency range for low Hz and High Hz

should be determined. Each cooler trace represents the spectrum of the activity of one data channel. The leftmost scalp map shows the scalp distribution of power at 6 Hz, which in these data is concentrated on the frontal midline. The other scalp maps indicate the distribution of power at 10 Hz and 22 Hz as shown in Figure 2.

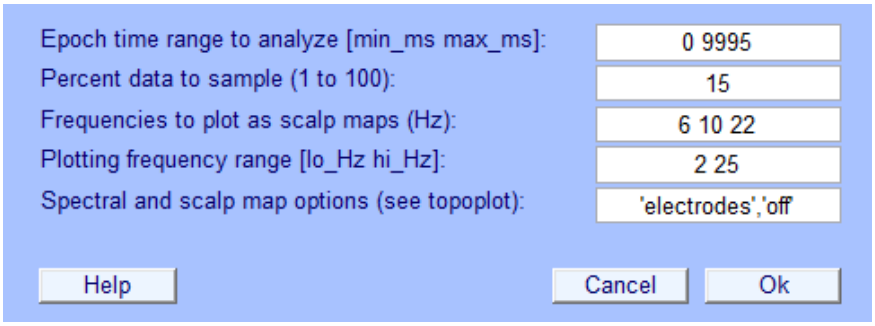

Figure 2. Data customization for channel spectral and maps (EEGLAB).

This window menu in Figure 2 allows the user to compute and plot spectra in specific time windows in the data. The percept data value can be used to speed the computation (by entering a number close to 0) or to return more definitive measures (by entering a number closer to 100). Note that functions also work with epoched data and we can plot the scalp location of a selected channel, its activity spectrum, and an ERP-image plot of its activity in single-epochs. Additionally with entire potentially for 2D representation for signals, EEG lab provides 3D visualization for whole channels, useful to know real position for signals reference in accurate place inside the brain.

8.5. Artifacts removing

Some EEG recordings involve subjects performing various visual tasks such as reading or watching video. Under these conditions, EEG may be susceptible to interference from the much stronger EOG signal arising from eye motion, particularly if EEG is recorded from near the front of the skull. Removing EOG artifacts helps to remove EOG interference from the EEG signals, recovering the EEG data for use in further analysis. The presence of artifacts, such as eye blinks, in EEG recordings obscures the underlying processes and makes analysis difficult. Large amounts of data must often be discarded because of contamination by eye blinks, muscle activity, line noise, and pulse signals. To overcome this difficulty, signal separation techniques are used to separate artifacts from the EEG data of interest [KN03].

By using AcqKnowledge software the EOG removal is performed using a blind signal separation technique known as Independent Component Analysis. ICA is used to split up statistically independent signals that have been mixed together during recording. Since EOG is independent of EEG, ICA can be used to remove it. In order to use remove EOG artifacts, a distinct EOG signal must be acquired in addition to the EEG signals. The EOG signal is required to identify the components correlated to eye motion. EOG artifact removal functions better when it is performed on multiple EEG leads simultaneously. Better results may be obtained by including EEG leads that do not exhibit EOG interference since the increased number of leads allows for more fine grained signal separation. Good results can be seen with as few as two EEG leads and one EOG lead. While this technique can be performed with a single EEG lead, the results will not be as dramatic. To use this process you should specify effected channels by selecting its label and then determining the channels that should be denoised, Figure 3 shows three channels that elicited the artifacts.

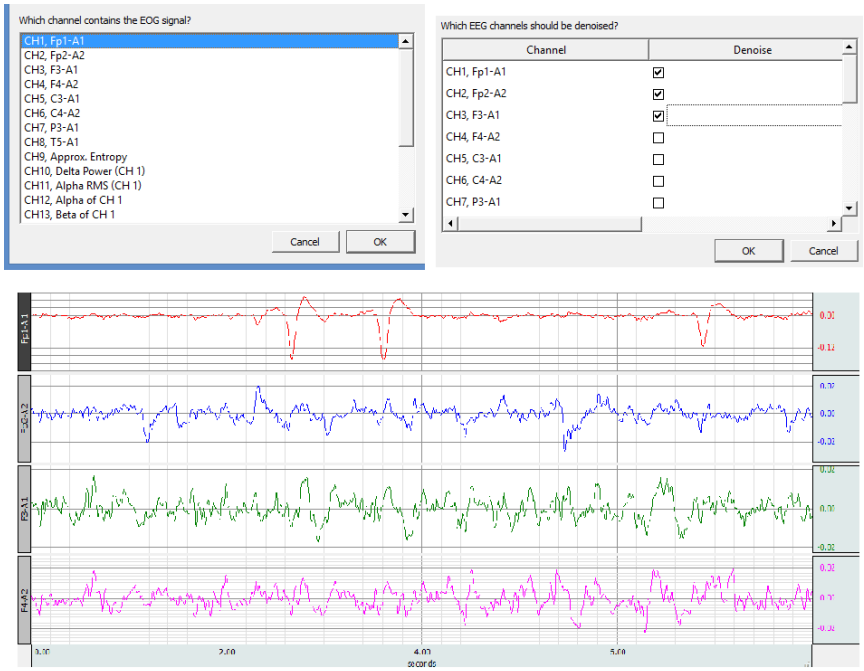

Figure 3. EOG removal using AcqKnowledge Tools.

On the other hand by using EEGLAB there are two ways to remove artifacts. The former is manual removing and the latter is automatic removing. In the first way,

data plotting is done as scrolling through the data of the current dataset, and then selecting each reign that contains signals out of standard range. We determine that by watching and focusing abnormal waves. These signals come from macule movement or external noise. When finishing the entire selection use a reject function to remove these reigns completely from the current file. This way is easy when you have short time recording but when there is a long time recording it becomes very difficult, therefore the second way, automatic removing, should be used. Using automatic artifact removal install external plugins for EEGLAB, one of popular plugins is AAR3.1, its free script could be downloaded from many websites[2]. To use this plugin after installing it, load dataset that contains row data, select the algorithm that gives better result. This plugin has five algorithms for artifacts removal: (BSS, LMS regression, RLS regression, Hinf EW regression and Hinf TV regression), for instance using BBS algorithm for noise removal. Empirical result of these methods shows the best approaches.

8.6. Independent Component Analysis (ICA)

Independent Component Analysis is useful for signal separation, de-noising, and advanced EEG analysis to remove noise signals or locate approximate regions of active processing centers in the brain [NR12]. ICA is a form of a statistical blind separation that attempts to separate mixed (overlapped) signals based on the assumption that they are statistically independent. ICA was applied to decompose the EEG into the Independent Components (Ics), the features of topographies and power spectral densities (PSD) of the Ics were extracted, and then manifold learning algorithm [HO00]. Usually run ICA using many more trials that the sample decomposition presented to finding n-stable components [DMW] that make this function here different than this used in artifact removal.

AcqKnowledge uses the FastICA algorithm to generate a new ICA graph with each component in a separate channel. Select two or more channels (all of the selected channels must have the same sampling rate). Specify tolerance and number of iterations. ICA limitations to consider for application and interpretation:

- The number of mixed sources must be equal to the number of independent components.
- Sources must be statistically independent; highly-correlated signals cannot be effectively separated.

[2] http://en.pudn.com/downloads648/sourcecode/math/detail2625728_en.html

- Sources must have non-Gaussian probability distribution. It is not possible to separate out components like white noise through ICA.
- Signal mixing must be a constant, linear process. Any type of non-linear signal propagation cannot be expressed in linear combinations of sources, the underlying assumption of ICA.
- The component sources (that is, point sources) must be stationary.

To explain action of ICA on the signals, Figure 4 shows this effected on five channels in addition, it represents mixing matrix for whole channels.

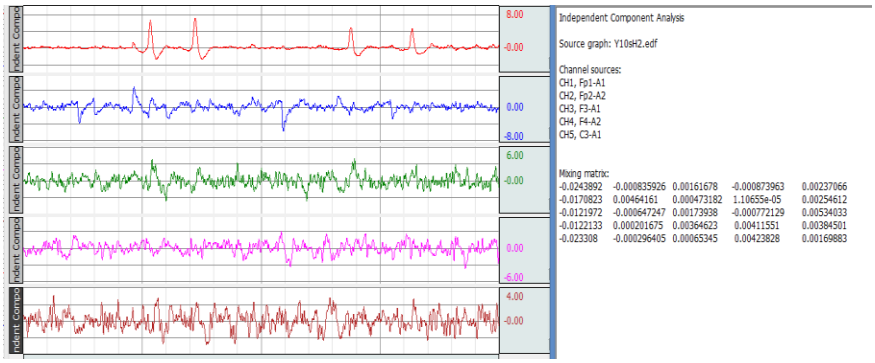

Figure 4. Executing ICA using AcqKnowledge.

By using EEGLAB tools most processing cannot be done without executing Run ICA. To perform separating for each channel without interrelation and to remove surrounding noise from original signal recorded by electrodes, we should run ICA on row data file after determining channel locations and then executing re-reference function. When execute RunICA function, we have many options allowing to try different ICA decomposition algorithms; these algorithms are runica, bincICA, jader, sobi and acsobiro. Details of how these ICA algorithms work can be found in the scientific papers of the teams that developed them [DMW]. In general, the physiological significance of any differences in the results or different algorithms (or of different parameter choices in the various algorithms) has been tested, standard runica applied to simulated, relatively to data sets for which all the assumptions of ICA are exactly fulfilled, all these algorithms return near-equivalent components. Notice we cannot do runica on a single channel. It should have at least three channels and we cannot view 2D visualization for data without executing this processing, this step always takes a long time depending on the size of recording.

8.7. Data filter processing

To understand how digital filters work, it is important to understand the nature of analog signals and their frequency components. All analog signals comprise of signals of various frequencies. The term digital filtering refers to a wide range of technologies that have in common the fact that they are mathematical procedures applied to discrete, numeric representation of continuous wave forms to emphasize or attenuate certain frequency [NM98].

EEG recording comprises of several different types of signals; each of them has a different frequency signature. Alpha waves (one of the most studied EEG signals) have a frequency range of about 8 Hz to 13 Hz. This means that alpha waves go through a complete cycle (from peak to peak or trough to trough) anywhere from 8 to 13 times a second. There are, of course, signals that have other frequency signatures in EEG data. Most types of physiological data have a number of different frequency signatures present in the overall signal. In addition, frequency components besides the signals of interest are often present.

Digital filtering is used to retain only the frequency components of interest and to remove other data (whether it is noise or merely physiological signals outside the range of interest). It is important to note that the way in which data is filtered depends in large part on the sampling rate at which the original data was acquired.

In AcqKnowledge you could do Digital filter by selecting an FIR filter type, the corresponding Digital Filter, allowing you to specify a number of different filtering options. The major option is for Cutoff Frequency (Hz) (or threshold). You should enter a fixed value or set to a fraction of the sampling rate or to line frequency. Sampling rate is set to a fraction of the sampling rate and automatically updates when the sample rate is modified. Line frequency is set to the line frequency at which the data was recorded, or you could fix at value guidelines as follows:

- Low Pass Filter: data with frequency components below the cutoff will pass through the filter, whereas frequency components above the threshold will be removed. For low pass filters, the default cutoff frequency is the waveform sampling rate divided by eight and can be set to any value between 0.000001Hz and 0.5 times the sampling rate.
- High Pass Filter: data with frequency components above the cutoff will pass through the filter, whereas frequency components below the threshold will be removed. For high pass filters, the default threshold is the waveform sampling rate divided by four and can be set to any value between 0.000001Hz and 0.5 times the sampling rate.

- Band-type Filters: a low threshold and a high threshold must be specified to define the band of data (the frequency range) that is either passed or stopped, depending on whether it is a Band Pass or Band Stop filter. In either case, the default for the low threshold is the waveform sampling rate divided by eight and the default for the high threshold is the waveform sampling rate divided by four. The threshold settings can take on any value from 0.000001Hz and 0.5 times the sampling rate, but the two thresholds cannot be set to the same value and the high threshold must be greater than the low threshold [ACQ].

To remove linear trends using EEGLAB, it is often desirable to high-pass filter the data, it is always recommended to filter continuous EEG data, before epoching or 96isualiz removal, although epoched data can also be filtered with this function (each epoch being filtered separately). Filtering the continuous data minimizes the introduction of filtering artifacts at epoch boundaries. Usually eliminate these undesired signals by enter 1 (Hz) as the lower edge frequency, in Basic FIR filter from tools in main menu. Figure 5 shows variable required to make filtering.

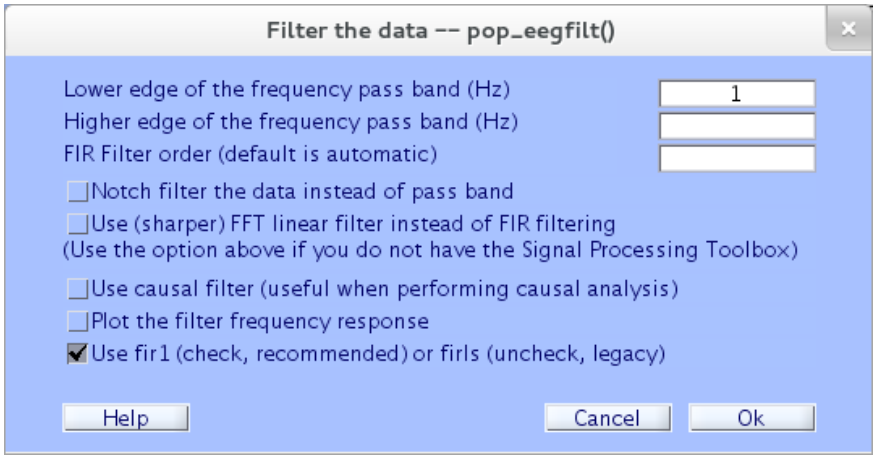

Figure 5. Data filtering in EEGLAB

If high-pass and low-pass cutoff frequencies are both selected, the filtering routine may not work. To avoid this problem, we recommend first applying the low-pass filter and then, in a second call, the high-pass filters (or vice versa). Another common use for bandpass filtering is to remove 50-Hz or 60-Hz line noise. The filtering option in EEGLAB uses linear finite impulse response (FIR) filtering. If the Matlab Signal Processing Toolbox is present, it uses the Matlab routine filtfilt(). This applies the filter forward and then again backward, to ensure that

phase delays introduced by the filter are nullified. If the Matlab Signal Processing toolbox is not present, EEGLAB uses a simple filtering method involving the inverse Fourier transform [DMW].

An infinite impulse response (IIR) filter plug-in is also distributed with EEGLAB. It uses the same graphical interface as the FIR filtering option described above. Although IIR filters usually introduce different phase delays at different frequencies, this is compensated for by again applying filtering in reverse using Matlab function filtfilt(). In practice, it is suggested to test the use of this IIR filter, as it is stronger (and shorter) than FIR filters. The basic comparisons are the number of multiplications per sample required in the usual realization of these filters [RK74].

We observed there are several operations could make it on row data using the AcqKnowledge software from EEGlab to do filtering like separated the signals into different bands, and it considered very important step for pre-processing signal to make classification or another operations.

8.8. Distinctiveness and differences

8.8.1. Statistical analysis

Distinctive among software that is used EEG signal in statistical analysis via the result of statistical data represented, the researcher can achieve many operations related to this event potentials. We observed using BCIlab which provides much data that had relations with statistical operations, but it works in closed environment, therefore we considered EEGLAB which provides closer finding with open environment, and we could observe using this tools to obtain graphical analysis and interpretation to facilitate the processing. The latter provides some estimated variables of the statistics printed as text in the panel on the bottom of a graphical result as appearing in Figure 6. This property cannot be found in AcqKnowledge software.

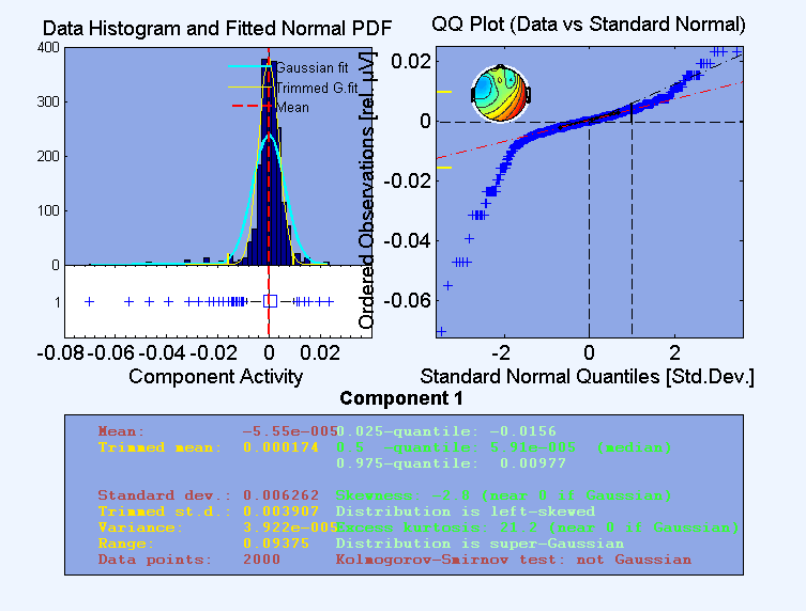

Figure 6. Statistical analysis result for seven channels during ten seconds (AcqKnowledge)

8.8.2.Frequency analysis

EEG may be characterized in terms of frequency and the power within specific frequency bands. The EEG Frequency Analysis script performs various feature extractions from EEG signals using FFT (Fast Fourier Transform [BO07]) and other techniques to examine the power within the EEG signals. This analysis may be performed for multiple EEG leads simultaneously, allowing for either analysis of multiple leads or analysis of multiple EEG alpha, beta, theta, or delta bands from a single raw lead. The EEG Frequency Analysis script divides the EEG signals into fixed-width time epochs. AcqKnowledge's Power Spectral Density function is used to estimate the power spectrum of that epoch using a Welch periodogram estimation method. From this PSD the following measures are extracted for each epoch. Here we explain this type of analysis for the same example in this paper but in different aspects. You could observe this result for one channel during ten seconds as appear in Figure 7.

	A	B	C	D	E	F	G
1	EEG Frequency Analysis, CH 1, Fp1-A1						
2							
3	Epoch width	200	Samples				
4	Spectral edge	90	percent				
5							
6	Epoch	MeanPower	MedianF	MeanF	Spectral Edge	PeakF	
7	1	5.0464E-10	11.62791	26.35659	30.23255814	4.651163	
8	2	5.838E-10	10.07752	23.25581	26.35658915	7.751938	
9	3	7.416E-08	5.426357	13.95349	12.40310078	5.426357	
10	4	2.074E-08	10.85271	27.13178	43.41085271	6.20155	
11	5	9.6247E-10	11.62791	21.70543	27.90697674	9.302326	
12	6	9.4845E-10	6.20155	19.37984	20.15503876	4.651163	
13	7	2.6542E-08	4.651163	10.85271	9.302325581	5.426357	
14	8	5.2729E-10	13.95349	27.13178	31.00775194	6.20155	
15	9	1.0113E-08	10.07752	21.70543	32.55813953	6.976744	
16	10	1.488E-09	6.976744	22.48062	24.03100775	4.651163	
17							

Figure 7. Result of frequency analysis (AcqKnowledge)

In this section we observe that EEGLAB tools need more to develop to reach this processing but it is found directly by one step in AcqKnowledge, because it makes for each individual time epoch.

8.9. Conclusion

Though characteristic study for application of EEG signal analysis observes function uses depending on analysis requirement and classifications, in this conclusion we will describe main point that makes function to do processing so different. We consider EEGLAB as better than other software for loading and importing data because it deals with many types of file format, and allows building spatial script to import any row data created in unknown devices or not more popular.

When comparing methods of displaying channels it can be observed that AcqKnowledge contains more than one possibility of control on this channels from EEGLAB such as (1- can scale to bandwidth for Separated channel and can apply to all channels, 2- can display time scale, 3- change color for each channels separately, 3- display background grid and adjust grid setting, 4- editing data for each channels separately). If you like to display 2D or 3D for acquired data you cannot make it in AcqKnowledge , but EEGLAB supports this type of visualization and has many characteristics not existing in other software.

Table 1. Comparison among EEG software.

	EEGLAB	AcqKnowledge	Other Software
File format	Could import 15 types and more (depending on additional toolboxes)	Loads 9 stationary types	File formats depend on device that is used to recording the data
Visualisation	Wide range of 2D and 3D visualization's features	No support for 2D and 3D visualization	Most of software's displaying with different ways, such as BCIlab support 2D viewing
Artifact Removing	Only manual removal or installing specific plugins (toolboxes)	Many customization possibilities for artifact removing	There is spatial software's for this purpose, BCIlab have many options but without specific details.
ICA execution	Supports 5 types of method with different parameters	Supports only one type which is Fast ICA	Not all other software's supported execute ICA, like BCIlab had only checkbox option to ICA without any details
Data Filtering	It uses only basic FIR	Supports many types of FIR and IIR algorithms and offers many options to customize filtering	Most of software supports filtering with FIR and IIR algorithms.
Statistical Analysis	Viewing data statistics for channels, components and events with many variable options	Limited support, only with some basic operations.	It depends on type of statistical analysis, such as BCIlab Allows for extensive statistical analysis of results.
Frequency Analysis	It supports only time frequency analysis	Contains many methods with various options for frequency analysis.	Most of these programs support time frequency representations

For artifact removing EEGLAB uses more than five algorithms to remove noise and you can determine more specific properties for this processing. Same things exists in ICA application because in EEGLAB there are many various text boxes. In addition there are five algorithm methods to run ICA when compared to AcqKnowledge. The last has only one algorithm it is FastICA.

In data filtering, featuring AcqKnowledge software more than EEGLAB, the former has many properties and functions affecting signals. The important functions are band-type filters to separate each band frequency range for delta, theta, alpha, beta and gamma with ability to determine these ranges, and isolate frequency band in separated window which makes it easy to export onto external file. You could see the result of comparison in the Table 1.

Every of these programs and tools is useful when you are researching in the brain signal processing. Each function had specific purpose depending on what you want to do on these signals. We have explained these major functions in more of popular software and tools to lead the research in these fields used optimal functions on these tools.

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