Advances on cognitive automation at LGI2P / Ecole des Mines d'Alès

Doctoral research snapshot 2018-2019
Foreword

This research report sums up the results of the 2019 PhD seminar of the LGI2P lab of IMT Mines Ales. This annual day-long meeting gathers presentations of the latest research results of LGI2P PhD students.

This year’s edition of the seminar took place on June 27th. Eleven PhD students and a postdoc researcher presented the research results they obtained in the past academic year. All presentations were followed by extensive time for questions and interaction with the audience.

The aggregation of abstracts of these works constitute this annual research report and gives a precise snapshot of the research led in the lab this year.

I would like to thank all lab members, among which all PhD students and their supervisors, for they helping me prepare this seminar. I would also like to thank all the researchers that came to listen to presentations and ask questions, thus contributing to the students’ PhD thesis defense training. A special thank to Jacky Montmain, head of the LGI2P lab for his continuous support. Thank you all for providing me with the context to organize this yearly event and our monthly research seminars which I initiated 10 years ago !

I wish you all an inspiring reading and hope to see you again for next year’s edition !

Christelle URTADO
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Abstract. The Health sector being a part of the Critical National Infrastructure entails a high risk, coupled with the ever growing of technology implementation in the health sector. The case of the French Mobile Field Hospital that employs the support of cyber assets to improve service delivery efficiency, in turn exposes it to certain threats. This research focuses on assessing the current organizational standards and procedure in using these assets, its users and their implementation, as well as proposing certain procedures, policies, strategies and technical know-how on how to achieve Cyber resilience. Reviewing and learning from recent cyber events and their impacts on the affected organization, in terms of preparing, detecting, responding and recovering from such. This is done through a series of cyber assessment methods, simulation exercises and the setup for vulnerability assessments of its cyber assets.

Keywords: Cyber, Resilience, Security, Hospitals.

1 Introduction

Cyber Security, being the body of technologies, processes and practices designed to protect networks, computers, programs, data and Systems from attack, damage or unauthorized access, includes both cyber Security and physical Security (Techtarget Magazine, 2017).

Living in an age where virtually everything is networked together, right from personal internet banking, all the way to government infrastructure, network Security is no longer an optional extra, especially in the Health industry. Just recently in May 2017, the WannaCry ransomware cyber-attack launched globally using hacking tools widely believed to have been developed by the US National Security Agency infected more than 300,00 computers in over 150 countries, according to Czech Security firm Avast (Graham, 2017). Focusing a major attack on one of the Critical National Infrastructure in the UK being the National Health Insurance Scheme (NHS), suffered a great loss via systems and networks denial of services, and loss of critical Patients records as well. Though many countries may have not recorded any cases, so far, officially in Mobile
Field Hospitals, this underlines the importance of the early nature and acceptance structure available as well as frameworks for reporting any cyber Security related issues.

More so, attacks are highly unlikely to slow down, with new avenues surfacing, such as the cloud third-party migration of data that may cause harm due to the creation of an epicenter that may give misappropriation opportunities, health care systems are no different in terms of the vulnerabilities. With technical innovation, comes new dangers, with mobile phones, tablets and wearables becoming more targets and machine-to-machine (M2M) used globally, both privately and in healthcare, coupled with the evolution of the Internet of Things to Internet of everything, which will eventually be responsible for a boost in information misuse.

2 Aim and Objectives of the research

2.1 Aim

The research aim is to evaluate the readiness and degree of implementation feasibility of the cyber Resilience in Mobile Field Hospitals which in turn may help other National Critical Infrastructure, and then develop an improved and effective Resilience Assessment framework and Standards of Operations for Mobile Field Hospitals to achieve maximum implementation, in terms of Protection, Awareness, Response and Investigations.

2.2 Objectives

1. The research will bridge the gap between the ever-growing digitization of the Hospital Records and use of Medical Devices, its adoption, and its Security implications, with relevance to achievement of the maximum Cyber Security strategy implementation of Cyber resilience assessment improvements in the Mobile Field Hospital.
2. Evaluate the factors associated with the Cyber Resilience framework, and their relevance to securing the digital cyber space of the Hospitals.
3. Develop an effective and improved cost effective strategy for achieving a maximum implementation process of Standards of Operation (SOPs) for prevention and response.

3 Methodology

This research will assemble various quantitative and qualitative research methods. The research will also dig in to a historical data of Mobile Field Hospital’s I.T usage, implications, implementation progress, policies, regulations and strategic action plan with regards to the both the mobile field hospital in context with reference to others.
This data will be collected from various data sources from Penetrations tests carried out on all possible data points and different scenarios and point of view. Equally, demographic data such as level of Cyber awareness, response and investigations capabilities will be captured and analyzed within the specified data collection point within the scope of the research.

Another supporting source of data for the research will include extensive research through the different published and unpublished materials, as well as the French Government Health Sector Publications, the French Mobile Field Hospitals (L’ESCRIM), other countries’ Mobile field hospitals, other NGOs and United Nations’ Publications.

Additionally, experiments, Penetration tests, cyber-drills/exercises and views from the Mobile field hospital and other Health sector players will be utilized using industry approved sources of past and latest trends, as well as immersions in real-life simulation exercises on general activities of Mobile Field Hospitals.

The issues to be explored during secondary research will be:

- A review of Cyber Security education and personnel development in the Mobile Field Hospital and/or Generally the Health Sector systems in France.
- A review of the strategic position of French Government Cyber Security policy within the global context of Cyberspace and its implementation in securing the Mobile Field Hospital Systems currently in use.
- Detailed statistics covering investment, penetration, and application and usage of Cyber Security tools in the protection of the Mobile Field Hospital categorised as the Health Sector’s National Critical Infrastructure.
- Detailed Statistics of French Cyber Security infrastructure with respect to third party devices and systems that have been implemented or deployed to be used in the mobile field hospital’s infrastructure or with patients.
- The competitive advantage France achieved so far in its General Strategic Cyber space Security investment, if any.

The Primary data will be collated through Certified and well-permissioned Penetration tests, past incidents’ thorough forensic investigation analysis, structured questionnaires, document reviews and interviews.

The following French MDAs will also be selected for some data collection

1. The ESCRIM (Element de Securite Civile Rapide d’Intervention Medicale)
2. French National Cybersecurity Agency (ANSII)

3. The European Union Agency for Network and Information Security (ENISA)


4 Concepts and Methods

4.1 State of the Art: Concepts

Resilience: Resilience definitions reviewed from a range of scientific papers, and a definition by Berkera (Berkera, 2013) was adopted due to its relative importance and relationship to the concept of cyber security and cyber resilience, in terms of preparedness, response and recovery.

![Figure 1: Berkera Resilience (Berkera, 2013)](image)

Cyber Security: Described as the practice of defending computers, servers, mobile devices, electronic systems, networks, and data from malicious attacks (Kaspersky, 2017).

Mobile Field Hospital: Mobile Field Hospitals (MFH) can be described according to the Farlex Dictionary, as the Hospital medical unit designed for the purposes of service provision and deployment in the field, which can be moved from place to place to meet up with the demands of certain situations such as emergencies, combat situations, disaster response purposes etc. (Farlex, 2012). According to the World Health Organization, it is defined as a mobile, self-contained, self-sufficient healthcare facility capable of rapid deployment and expansion or contraction to meet immediate emergency requirements for a specific period of time (W.H.O, 2003).

Application of IT in MFH: The application of IT infrastructure and devices in the MFH and health sector in general in the form of cyber assets to improve the quality and efficiency of service delivery. Some of the assets deployed include Local area network (LAN), Wide area Network (WAN), Computers/tablets, Barcode scanners, smart medical devices etc.
Disaster management: perceived preparation of hospital workers

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Abstract. This thesis project that began in October 2018 and will end in October 2021, is introduced in this report. The work accomplished is provided in part two.

Keywords: Disaster, Crisis management, Perceived preparation.

1 Project summary

Disaster, defined within the French department of health as a situation that exceed the usually operations of health care system [1] will increase [2]. It is important for hospitals and hospital workers to be prepared for disaster management in order to be efficient in their organization [3]. However, there is a lack of scientific literature about how prepared hospital workers really are for a disaster situation. Therefore, French hospital workers’ perceived preparation is unknown. This thesis will study this perception and its determinants using a psycho-social approach.

From a theoretical perspective, this thesis will improve general knowledge on risk perception and social representation of disasters. Both theoretical tools will allow a comprehensive and descriptive approach to understand the perceived preparation.

From a practical point of view, this thesis will improve the understanding of the preparation process, and thereby, improve disaster-management in hospitals.

1.1 Aims

The general aim is to understand how hospital workers perceive their disaster management preparation. Thanks to this analysis, we have put forward four general objectives:

1. Identify what they think a “disaster situation” is
2. Identify what they think “preparation” means
3. Measure their level of perceived preparation
4. Identify the different factors that will influence this perception
2 Work accomplished

The problematization and general aims were established during the first year. Based on these aims, we were able to design three studies.

The first study is based around conducting semi-structured interviews in order to respond to the first two aims (identify what they think a “disaster situation” is and identify what they think “preparation” means). The second study includes conducting hierarchical evocations surveys in order to respond to the first aim (identify what they think a “disaster situation” is). Both the first and the second studies will lead to writing a questionnaire that will be distributed in the third study. This investigation is in order to find the answers to the 3rd and 4th aims (Measure their level of perceived preparation and identify the different factors that will influence this perception).

The first two studies have begun. Below, we report the first steps accomplished.

2.1 The first study

In this study, we used theoretical frameworks of social representations, perception and risk perception. Therefore, the specific aims are to:

1. Identify their social representations of disasters
2. Identify their risk perception of disasters
3. Identify their representations of disaster-preparation

Forty-five interviews have been conducted with twelve doctors, eleven paramedics, twelve health care managers and ten administrative workers. The participants work in eight different French hospitals (CHU d’Angers, CH d’Avignon, GHT Gap, CHRU Lille, HCL Lyon, CHU Montpellier, CHU Montpellier, APHP Paris) and we have transcribed thirty-two interviews.

2.2 The second study

In this study, we used theoretical frameworks of social representations, however, we used a structural approach. Therefore, the specific aim is to

1. Put forward hypotheses on the content and structure of the social representation of disasters

One hundred and four hospital workers replied to the questionnaire. Forty-four responded to the questionnaire during their interviews (study one) and sixty responded to the online version. The respondents were; twenty-two doctors, twenty-two paramedics, seventeen health care managers and twenty-two administrative workers.
References

EBCR : Empirical Bayes Concordance Rate to weight similarity measurement within collaborative filtering recommendations

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Abstract. Recommender systems consist in providing users with relevant items by predicting their preferences. By this way, the system helps users to navigate efficiently in a large product catalog. To fulfill the prediction of the tastes of a particular user, collaborative filtering, a widely used mechanism, relies on the tastes of other similar users. Thus, the way a user’s neighborhood is identified strongly influences the prediction accuracy. Most methods estimate user proximities based on the consistency of the ratings they have assigned to co-rated items, regardless of the number of those co-ratings. In this report, we introduce a similarity adjustment that accounts for this number of co-ratings and improves existing similarity measures without increasing their time complexity. Experiments conducted on a benchmark dataset confirm the benefit of our contribution.

Keywords: Recommender system · Similarity measurement · Collaboratif filtering · Empirical bayes

1 Introduction

The amount of available data increases exponentially. Intelligent systems are therefore needed to help users crawling the huge collections of resources and finding the relevant ones they need. Recommender systems are such systems that have the ability of accurately predicting user preferences on items and making recommendations. Many e-commerce sites, such as Amazon, rely on recommender systems to help users navigating efficiently through huge product catalogs. Such tools help users not to feel lost when confronted to plethora of offers.

Three typical recommender system approaches exist in the literature: i) the content-based filtering approach (or CBF in short) [2] which recommends to a user items that are similar to the ones he has highly rated; ii) the collaborative filtering approach, i.e. CF, [4] which provides the active user with items that were highly rated by users having similar tastes; and iii) Hybrid recommender
systems, which combine the two previous approaches to make more accurate recommendations [3]. The investigation here focus mainly on collaborative filtering approaches, more specifically, memory-based CF approach, which consists in predicting user ratings on items by exploring the whole user-rating matrix.

Similarity measurement is an important task within the CF process, as for predicting the rating value of a particular user for an unrated item, we need to determinate firstly his neighbor users. This is achieved by searching for users having the most similar rating vectors.

To calculate the similarity value given two users' ratings, classic measurements proposed in the literature such as PCC (Pearson Correlation Coefficient), COS (Cosine similarity between two vectors), MSD (Mean Square Distance) only rely on rating values of their co-rated items regardless of the number of these co-rated items. This often leads to unreliable results, especially for users who co-rated very few items. The section below presents our weighting factor, based on rating concordance, which can be combined with state-of-the-art similarity measurement to get better rating predictions.

2 Empirical bayes concordance rate

In this section, we present EBCR, namely Empirical Bayes Concordance Rate, a weighting factor which can be combined easily with different state-of-the-art similarity measurements in the context of memory-based collaborative filtering algorithms and improves the prediction accuracy. Formally, to predict the rating value that user \( u \) might given to an item \( i \), denoted \( \hat{r}_{u,i} \), the CF algorithm identify the \( k \) nearest users of \( u \), denoted \( v \) below, and proceed as follows:

\[
\hat{r}_{u,i} = \frac{\sum_{v \in N_u} r_{v,i} \cdot \text{sim}(u, v)}{\sum_{v \in N_u} \text{sim}(u, v)}
\]  

(1)

where \( N_u \) is the neighbor set of user \( u \), \( r_{v,i} \) represents the rating given by the user \( v \) on the target item \( i \) and \( \text{sim}(u, v) \) represents a similarity measurement to quantify the similarity between \( u \) and \( v \). Thus, the predicted rating value for user \( u \) on item \( i \), i.e. \( \hat{r}_{u,i} \), is a weighed average of ratings given by its neighbor users.

The proposed EBCR approach has two consecutive steps. Firstly, for each user pair \( (u, v) \) we define and calculate \( CR \), i.e. the concordance rate based on their rating distributions. Formally, The \( CR \) rate represents the proportion of concordantly co-rated items among all set of their co-rated items, i.e. \( CR_{u,v} = \frac{|C_{u,v}|}{|T_{u,v}|} \). An item is considered as concordant for users \( u \) and \( v \) if they have the same taste on that item, i.e. \( T(u,i) = T(v,i) \) where the \( T \) function can take values from the set \{like, dislike, uncertain\}. The second step is the core of the proposed approach, which aims to adjust each of these calculated concordance rates. The reason for this adjustment is: most of these values are not reliable due to the lack of evidences. Considering three users \( u, v \) and \( w \), \( u \) and \( v \) co-rated
only 3 items and have the same tastes on them, thus, \( CR_{u,v} = 1 \); \( v \) et \( w \) had 2000 co-rated items and expressed same preferences on 1900 out of these 2000 items, thus, we have \( CR_{v,w} = \frac{1900}{2000} \). According to this result, we presume that user \( u \) is more similar to \( v \) than to \( w \), which is counter-intuitive. Moreover, most of the time, users only rate a little proportion of a huge catalog of items, which leads to unreliable results. To adjust the \( CR \) rates, we employed empirical bayes method, which consists in considering all of the concordance rates as a prior distribution of probability that two users may have concordantly co-rated items. To this end, we fit hyper-parameters \( \alpha_0 \) and \( \beta_0 \) to the training data and use them to adjust \( CR \) values. We call it \( EBCR \), which equals to \( \frac{|C_{u,v}| + \alpha_0}{|I_{u,v}| + \alpha_0 + \beta_0} \). We then weight classic similarity measurements \( sim(u, v) \) of the equation 1 to get a new value, as follows:

\[
sim_{EBCR}(u, v) = \frac{|C_{u,v}| + \alpha_0}{|I_{u,v}| + \alpha_0 + \beta_0} \times sim(u, v)
\]  

Evaluations of the proposed approach in term of prediction accuracy were conducted on a benchmark data set of movie ratings and the figure 1 below shows the results which confirms the benefit of the proposed approach.

![Fig. 1. Contribution of EBCR for different classic neighborhood measurements within collaborative filtering](image)

3 Synthesis and perspectives

The aims of the thesis is to investigate ways of leveraging ontologies (more generally, knowledge bases) and recommender systems. For this purpose, literature
studies have been conducted both on recommender systems, *i.e.* to understand what recommenders are, what are basic approaches, how do they work *etc.* and on ontology-based recommenders, *i.e.* to learn what are pros & cons of integrating RS with ontologies and to discover new research directions. To this end, one first state-of-the-art review paper was submitted and accepted [1] by the IC 2019 conference. Next steps of the thesis will consist in investigating new research directions (*e.g.* explainable recommendations, diversification of recommendations, *etc.*) of integrating recommender systems with knowledge models.

References

Incremental development of an embedded system in order to help prevention of burnout: issue and literature review

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Abstract

This summary presents the advance of the thesis initiated in November 2018, as well as a synopsis of the literature review on burnout syndrome. We seek to study the contribution of a formal incremental development approach in the field of health and mobile applications, to specify, design, evaluate and develop a software solution to assist in the diagnosis of this syndrome. We explain the choices made so far for both the psychological side and the computer side. The particular case of burnout seems appropriate to this type of research. Formal approaches allow early detection of specification and design errors. These formal approaches will be associated with an incremental development technique maintaining the system’s liveliness and safety properties throughout development. We will also use the Agile approach to promote exchanges between users and designers. The realised system aims to meet the non-functional requirements of reliability, robustness, performance and usability.

Keywords: burnout, mental load, stress, formal approaches, Agile approach, incremental development.

1 Introduction

Our work aims to study the feasibility and the interest of a formal and incremental approach [19, 20] for the development of a detection system of situations at risk of burnout. This system will consist of an application for health care professionals and another application for individuals. Through this object of study, we seek to know how the incremental and formal approach [19] makes it possible to account for the multi-factorial aspect of the human behaviours present in the case of burnout syndrome. This objective is justified by the fact that, on the one hand, health applications require a high degree of reliability, hence the interest for formal approaches, on the other hand the multiplicity of factors and input data encourages us to follow a spiral approach, aiming to consider only a few factors initially.

To address this issue, we must first and foremost familiarise ourselves with the work done by researchers in the humanities and social sciences and health care professionals to define burnout syndrome. Several angles of approach have been formulated. Indeed, burnout is seen as the final state of the individual breaking up as well as a process leading to the final state of rupture. We made the decision to consider burnout as a process. Burnout is a complex multi-factorial phenomenon that requires taking into account the individual’s work situation, but also their psychological attributes. We will therefore develop an application for health care professionals to assess the professional and personal situation of the individual. A second application will also be developed to obtain physiological,
physical and behavioural data on the individual. It is the combination of these two sources of data that
will allow the health care professional to make a diagnosis.

The application does not pretend to be a substitute for health care professionals, the only ones able
to make a diagnosis and make recommendations. We want to provide them with a “toolkit application”
that allows them to combine the data they need to diagnose.

The formal approaches allow to form part of a process of formulation and specification of the
requirements (who, what, why, with what qualities) but also of design, evaluation and development
closer to the user needs (for what, for whom, by whom, by what and how).

In this summary, an overview of the work done by psychologists on burnout is given, as well
as a panel of markers that can be used to identify states of stress, anxiety or mental stress. Then,
we describe the approach we will follow to respond to our problem. Finally, we present our present
perspectives.

2 Burnout and stress indicators

2.1 Main approaches

The burnout syndrome is a growing societal phenomenon [1], reflecting the malaise of some employ-
ees in their company or institution [15, 13, 3, 2, 5]. The causes of this state have their roots in the
professional sphere. Burnout benefits from more than fifty definitions in the scientific literature [17,
34, 31]. It is not recognised as a disease and is therefore not listed on the occupational diseases chart
[14].

The first work on the concept of burnout was conducted by Freudenberger [7], starting in 1974,
and continues today with, for example, the work of Gil-Monte [9] in 2012. In view of the number of
definitions since 1970, the different theoretical and empirical approaches used, or the different tools
developed, the definition of burnout is evolving as a result of the many studies carried out.

In the 1970s, for Freudenberger, it is “la maladie du battant” and for Maslach and Jackson, less
than ten years later, it is a “three-dimensional syndrome”. [27].

There are several points in common to these theories. The first is to identify that there is a strong
break in meaning in the individual. Break between the meaning of the individual and the tasks he car-
rries out daily. Another common point concerns the organisation of work (planning, number of tasks,
level of responsibility, room for autonomy). It plays a determining role in the appearance of the syn-
drome. The causes of burnout are rooted in the professional sphere. Another common point identified
relates to the individual himself his personality. Two individuals living the exact same situation will not
have the same feeling, thus not applying the same “coping strategy”. This brings us to the last common
point identified, namely that burnout is a coping strategy put in place by the individual. It corresponds
to the last wall of protection of the individual to get out of a situation perceived as dangerous.

2.2 The Maslach’s approach

The Maslach’s work [27, 24] dominate the literature. Both her theory and the tools she developed are
used by researchers to understand and evaluate burnout syndrome. Maslach is particularly interested
in professions called caregivers where the relationship with the user is almost permanent. It will also
assume at the beginning that this syndrome can be observed only among these types of professions: hospital staff, police, teacher.

The three dimensions she identifies to describe this syndrome are: 1) emotional exhaustion, defined
as the feeling of being invaded or exhausted by her work, 2) depersonalisation, which manifests itself
by feelings of insensitivity and impersonal responses to clients; and 3) personal accomplishment at
work, translated by feelings of self-competence and self-fulfilment at work. Burnout is characterised
by a high level of dimensions 1) and 2) and a low level of dimension 3). A tool called MBI — Maslach
**Burnout Inventory** — has been developed in this sense, as we will see in the paragraph 3. We plan to integrate the MBI in our toolbox for the health professional.

---

2.3 **Our understanding**

We do not approach burnout as the state of rupture but as the process leading to this state of rupture. Indeed, burnout is the result of a mental load\(^1\) [12] repeated and elevated, the effects of which are cumulative with those of a poorly adapted organisation: resources tend to fall, especially with regard to the workload, which increases, where autonomy is not or little valued, where a loss of meaning operates for the individual between what he thought to achieve in the company vs what he is actually doing.

The main notions that we retain are presented in the class diagram of the domain (fig. 1). We distinguish five categories of classes:

---

\(^1\)Mental load is a term that has recently become popularised for the invisible, cognitive load of organising everything in the domestic sphere: household chores, appointments, shopping, childcare, etc. This term first appeared in the private sphere and as incumbent on women. Monique Haicault is the first sociologist, French, to bring out this term.
• concerning the subject, eg the individual whose burnout is to be monitored: his personality, his physical and psychological characteristics, his mental load, his sensory perceptions, his physical and cognitive capacities and finally his evolution personal;

• concerning the human and organisational context of the individual: the company in which he works, his personal and social environment. It is also in this category that we place the health professional who follows him;

• burnout syndrome, which is underlined here a cause or a “utility” (coping strategy) and consequences;

• all the symptoms that characterise burnout. We highlight here Maslach’s three emotional dimensions: feelings of emotional exhaustion, depersonalisation and fulfilment;

• finally, seeing burnout as a process whose evolution we want to monitor: this process reacts to endogenous or exogenous events, and produces actions (tasks).

The syndrome of burnout has been widely studied among the same types of professions (cf. paragraph 2.2). Research work for these professions dominates the literature. Work on other professions has been emerging for about ten years, for example, about farmers [23, 22].

Our working hypothesis is that, regardless of the individual’s job, burnout can be described as a process. This process involves steps, internal and external events, action events, perhaps cycles, or even possibly concurrent states.

Without stopping to a single definition, it is possible for us to say that burnout is the result of a period of intense and repeated stress, lived as a mental load, whose triggers occur first in the environment professional before invading the personal sphere. Burnout would arise specifically in a work context and be defined as a response to excessive and/or continuous stress at work.

Measuring physical, physiological and behavioural data is necessary to identify the threshold of passage between the different transient states inherent in the process of burnout. By recording this type of data, we can assess the relevance of limiting it or not.

2.4 Stress indicators

Stressors have been measured and validated through several studies, we can find a summary in [4]. Stress is identified from the symptoms that result. For example, some symptoms recognised to date are physiological such as headaches or muscle aches, sleep disorders, appetite, repetitive infections. Other symptoms relate more to the behaviour of the individual, such as emotions with increased intensities, the use of products such as “sedatives” (tobacco, alcohol), inhibition, withdrawal, forgetfulness, errors (repeatedly), and this over a long period [34].

Some indicators seem, to date, difficult to observe via sensors on a mobile phone (alcohol consumption or tobacco, repeated infections). Others seem observable (possible sleep disorders as well as the period concerned and its duration for example). The selected indicators will be implemented as development progresses.

3 Existing tools and digital applications

3.1 Questionnaires

Thanks to the research of Freudenberger, Maslach, Lieter, Schauffeli, Cherniss, Farber, Siegrist, Karasek and others, many questionnaires exist and serve as a tool for assessing burnout. It is not possible to name them all. The best known are [21]: Burnout Questionary by Freudenberger and Richelson (1980), Individual Burnout Symptomatic Questionary by Appelbaum (1980), Staff Burnout Scale by

The most used tool, the Maslach Burnout Inventory (1980) [25], has remained for a long time without translation and therefore only usable for Anglo-Americans. A French translation is available. It was developed by Canadian scholars [6] and is less relevant to French culture. Having proven itself in Canadian culture, MBI has also performed well on so-called caregiver populations. It must be kept in mind that it was developed for them.

One limitation of these tools is that the diagnosis is based on results produced by self-assessment tools. We do not question the usefulness of a self-assessment questionnaire because talking about what goes “wrong” is already a step in the process of acceptance and hence of “healing”. However, the self-evaluation character makes it a tool asking questions about the sincerity of the answers. Indeed, if burnout is a syndrome of employees most committed to their work with values assumed, they can often go through a phase of denial of their condition. Can we really be content with a questionnaire of this type? What would be the added value of a “toolbox” to prevent these situations of intense and/or repeated stress leading to burnout?

Finally, these questionnaires have been validated on specific populations (cf. paragraph 2.2), each time in a national context, and therefore cultural, also specific. We did not find any work observing the helpers in Paris and the carers in Madrid for example. The question of the profession then arises. Is it a key determinant in understanding the process leading to burnout? Or can we overcome this parameter and detect situational similarities leading to this exhaustion?

3.2 Digital applications

We are interested here in applications developed on tablets and/or mobile phones, evaluating the following questions: Is it a market? Who are the users? Do they incorporate other tools than self-administered questionnaires? Are they “popular”? We will only talk here about half of the applications, dealing with stress, already identified, around twenty.

These applications are related to stress and/or anxiety, sometimes even depression. Only one application is named burnout. The others never speak directly of burnout but rather of stress or anxiety. Most of these applications are available in English. They are addressed directly to the individual and not to a business leader or a human relations manager, for example, and even less to a health professional type of occupational physician or psychologist of the company. These applications can be divided into four families:

1. First one is the result of the management of stress or anxiety experienced, perceived by the individual. These applications assume that the individual is aware at a given moment of being in a state of stress or anxiety.

2. The second family of applications allows to detect a possible state of stress or anxiety and then to provide an aid to understand the condition.

3. The third family is that of applications indirectly related to a “diagnosis” stress. They are based on a followed by measurements of physiological factors such as heart rate, blood pressure or the quality of sleep to observe whether there is a state of imbalance and therefore stress.

4. The fourth family concerns applications for (senior) managers of the company and developed by health authorities or recognised but non-governmental organisations. This family contains only one application for the moment. It seems important to distinguish it from other applications for several reasons. First, we must mention that the applications described above are developed
in collaboration with developers and psychologists and/or psychiatrists, or a person who has experienced burnout. *A contrario*, this application is developed by The International Labor Office (ILO). The application of the ILO is totally free and free. This application, called “Checkpoints or Workplace Stress Prevention”, is not for the individual but for the business entity. This could be compared to a complete guide where ten dimensions are identified, such as "Leadership and justice at work", "Job demands", "Social support", etc., for which five items build a dimension, that is fifty items in total. This exhaustive list of control points allows the company to choose its own. This makes it possible to build a customised tool according to the type of organisation, from the complete ILO tool. ILO also indicates in this guide how to use their list of checkpoints. For example, organising workshops or training days for employees. This tool is interesting. It is distributed via the channels for digital tools for personal use and integrates stress at work as real, worthy of interest and for which the company has a role to assume [29]. Finally, although the other applications are free of installation, they all include a paid part if you want to upgrade or access all options — some applications of the third family escape this rule.

All these applications appeared in early 2010. They come from North America, France, Spain, Germany, England, Australia, India, etc. The number of downloads exceeds 500,000 for some and has tens of thousands of notes and comments.

The limits that we perceive to this type of application are the self-rated character — the same limits as for the questionnaires —, the lack of connection with a health professional — only able to decide the possible support of the individual —, or access to paid features to benefit from the entire application.

Our application differs from existing ones in that we want to provide a system (mobile application and web application) where health care professionals will benefit from a toolbox to help them prevent situations of risk of exhaustion. The individual must not be left alone to make his own assessment and interpret it. This view is shown in Figure 2, where we see that the diagnostic aid system compares a syndrome of burnout “reference” with the actual evolution of the subject. The web part of the system can be in contact with several health care professionals to help them make their diagnosis.

Figure 2: Class diagram describing the interaction of the system with its environment.
4 Which approach to follow?

The development phases of the embedded system will be carried out iteratively to allow a regular return trip with the users to validate or invalidate the developments as and when. As for the verification of the relevance of the functionalities developed with regard to the needs, it will result from the tests with the health care professionals.

The IDF [19] method of behavioural specification support is an incremental construction framework formed:

- of a set of evaluation techniques between two stages of specification: use of comparison relations (equivalences and pre-orders) between two behavioural specifications, seeking to detect if the new specification does not allow behaviours that it should not not allow (safety properties), as well as if the new specification does not prohibit behaviours that it should allow (vivacity properties);

- of a set of construction techniques. These techniques are based on construction operators allowing to follow horizontal steps, by extension or restriction of functionalities, as well as vertical approaches, by refinement or abstraction of behaviour. The specifications are given either as UML composite components whose behaviours are defined by UML state machines, or as processes described in a process algebra.

It is therefore an application of formal methods (process algebras, labelled transition systems and verification, refinement and incremental construction techniques) associated with Agile methods.

We want to develop a tool that is neither intrusive to the individual nor time consuming. That’s why we decided to use only the components available on mobile phones. A program to detect the components present on the phone of the individual will have to be integrated into our system in order to anticipate the measures that can be taken. In the absence of a given component, we will have to find a way to substitute the information sought either via another component or via the combination of several components. An assessment of the accuracy of the measures identified will have to be made in order to obtain and/or build reliable indicators, complementary to the existing psychological tools.

5 Perspectives. Conclusion.

The work of psychology researchers provides an essential foundation for the detection of burnout syndrome. Several currents exist. The psychological nature of burnout must be measured in order to understand the multi-factorial aspects of this syndrome. It is then up to us to assess whether these multi-factorial criteria can be detected solely by physiological, physical and behavioural measures without the need to use psychological assessment tools. The originality of our approach is to understand burnout as a cross-business process, and in particular we aim to model it using formal process description techniques. As part of the validation of our research, two options are envisaged: the first being to use the questionnaires and the second to be inspired by the work done at the University of Louvain in Belgium on “The parental burnout” [30]. These researchers use cortisol, the stress hormone contained in the hair to detect the stress level of parents. The interest is to obtain a history of the level of cortisol in the subject, a history that can not be obtained by saliva. This measure could serve as a criterion for the external validity of our own measures.

Health is a sensitive area because of the survival’s issues for individuals. The risk of having false positives and false negatives should be as low as possible. This is why we have chosen to combine the IDF method (formal approach and incremental development), the Agile approach and the tools used in the human and social sciences.
References


Analyzing the Software Architecture Configuration Practices in Java / Spring Projects

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Keywords: Software architecture, architecture deployment, architecture configuration, empirical software engineering, Spring framework, GitHub open-source project.

1 Introduction

Architecture design is a critical issue that impacts software engineering [1]. Architectures are the natural consequence of modularity: They compose software from elementary components that can easily be developed, tested, maintained or reused.

Spring is a popular industrial framework designed for architecture development in Java. As established by a survey involving 2044 developers[^1], it is the most used framework for web-service development. Spring has evolved over time with technologies (e.g., adoption of Java annotations) or application needs (e.g., automation of deployment). Spring now provides developers with multiple features, that complement one another and sometimes overlap, for the architecture definition.

Section 2 motivates this work. Section 3 first describes the features provided by the Spring framework then compares them with respect to expected qualities. Section 4 describes the empirical study on developers’ practices. To conclude, Section 5 draws perspectives for this work.

2 Motivations

Architecture models are used in nearly all steps of the software lifecycle, from its early design, as an abstract, ideal solution to meet users requirements, to its actual deployment and execution. The ideal technology should both be flexible and easy to use for software developers and help document the architecture, increase component reusability and maintainability and manage change for software architects.

Defining a software architecture amounts to describe its components and their connections (the links that support their interactions). In the case of Java software, this amounts to define the constituent objects and the reference bindings to be created at runtime. When no specific architecture management feature is available, architecture construction is classically hard-coded in the main procedure. Otherwise, an architecture deployment descriptor can be defined through a framework to set the architecture up. To compare their modeling capabilities, we have established a set of expected qualities: Explicitness. Explicit architecture models are defined with dedicated elements, clearly separated from source code.

Listing 1.1: XML descriptor bean configuration

Listing 1.2: Annotation-based bean configuration

Listing 1.3: Annotated components

Listing 1.4: Autowired configuration

Declarativity. Declarative architecture models are defined by abstract elements, that specify the expected instantiated structures, not the instantiation code.

Encapsulation. Encapsulated architecture model definitions are not scattered across source code but gathered into modules.

Assistance. Assisted architecture design is supported by tools that verify consistency, use of good practices or architectural styles, and control evolution to prevent architecture drift or erosion [2].

3 Spring Features and their Qualities

Since Spring 4 (2013), three closely related architecture definition features are offered to developers:

XML descriptors. Architectures are defined by several XML descriptors that are parsed and interpreted at runtime by the Spring container. Architecture components are declared by the <bean> tag. Listing 1 defines a small home automation architecture composed of an Orchestrator object connected to a Lamp and a Clock. Connections are defined by binding bean properties to bean references, as declared by property tags.

Configuration classes. Architectures can alternatively be defined by specific Java classes, identified by the @Configuration annotation (see Listing 2). Configuration classes are automatically detected by the Spring container and executed to build the architecture. Beans are declared by methods annotated by @Bean.

Self-annotated classes. Architecture definition is integrated to the code of the supporting classes thanks to annotations. The @Component annotation identifies the classes that will be automatically instantiated by the container to create architecture beans (see Listings 3 and 4). Similarly, the @Autowired annotation identifies dependencies (i.e., connections) that will automatically be supplied by the container. On the one hand, self-annotated classes are the most declarative way to define architectures. On the other hand, architecture definitions are scattered through and mixed with source code.

Moreover, Spring also supports any combination of the aforementioned architecture definition features.

Feature Quality Analysis. XML descriptors and configuration classes enable explicit and encapsulated architecture definitions. Regarding modularity, configuration classes leverage the object-orientation of Java. Considering these three qualities, configuration classes are the best choice and self-annotated classes the worst. This analysis is coherent with technical literature that recommends to limit the use of self-annotated classes to small projects [3, 4]. Besides, self-annotated classes define architectures only with
singleton classes. Rather than a limitation, this constraint is intended to enforce strong cohesion between class and architecture structures. Two antagonist approaches of architecture definition are thus supported: architectures that are orthogonal (generic and flexible) or integrated (to avoid architectural drifts) to the code of classes. Self-annotated classes therefore are recommended for projects that are subject to frequent changes [3]. When it comes to choosing features for architecture definition, technical literature only provides scarce guidance, often considering this choice as a matter of developers’ tastes [4]. Furthermore, to our knowledge, the qualities of architecture definition mixing features have not yet been studied. We expect that these feature combinations result from rational decisions of experienced developers that use the most adapted feature to different parts of architectures.

4 Empirical Study of Developers’ Practices when Using Spring Framework

Data Extraction. A corpus of 524 projects has been extracted from GitHub. We selected projects with 100 stars or more, forked at least 10 times, written in Java, containing the “Spring” keyword and created after 2010-01-01 (i.e., after Spring release 3).

Empirical Analysis. To understand the state-of-practice, we first analyzed which Spring features where used in the studied corpus. Surprisingly, a majority of Spring projects mixes architecture definition features (≈ 69.3%) and, despite their qualities, configurations classes are only used in a minority of projects (≈ 6.5%). They are challenged by XML descriptors (≈ 12.6%) and self-annotated classes (≈ 11.6%). Apart from routine, in the case of XML descriptors, which are the oldest proposed feature, declarativity may thus be a key quality in developers’ decisions. Figure 1 presents the distribution of all the combination of architecture definition features, depending on the size of the projects measured with the Source Lines Of Code (SLOC) metric. As expected, self-annotated classes alone are only used in small projects. Surprise comes again from configuration classes, that are used alone in only rather small projects. Explicit and encapsulated architecture descriptions do not appear to be a primary concern. Again, declarative features are rather used in bigger projects and even the biggest ones. More interestingly, the biggest project seems to require the support of all the features together. To confirm the intuition that project size has an impact on used features, we evaluate two hypotheses using a non-parametric statistical Kruskal-Wallis test:

- **Null hypothesis** $H_0$ : No influence of architecture definition features on project size.
- **Alternative hypothesis** $H_1$ : Influence of architecture definition features on project size.

Defining risk $\alpha = 5\%$, the result of the test is $H \approx 93.68$ with a $p$-value of $\approx 5.196^{-18}$. As $p$-value $\leq \alpha$, the null hypothesis $H_0$ is rejected with a 5% risk. This demonstrates that architecture definition features have a significant influence on project size.
As the choice of architecture definition features by the developer obviously does not determine the size of the project, we can infer that the correlation we measure is the reciprocal relation of the actual situation: the choice of architecture definition features is influenced by the size of the project. It would be interesting to study whether the choice of the technique is done \textit{a priori} or evolves, depending on the size of the project.

Finally, we also analyzed isolatedly the use of self-annotated classes on the corpus of 524 Spring projects, depending of their size, using a chi-square test. This test rejects the hypothesis of a relation between project size and use of self-annotated classes, confirming the intuitive analysis of Figure 1. Usage of self-annotated classes thus seems definitely motivated by declarative convenience rather than sound modeling capabilities.

5 Conclusion and future works

The empirical analysis we have run on a corpus of 524 projects extracted from the hosting GitHub service about the usage of the architectural definition features provided by the Spring framework leaves opened questions. It shows that usage is strongly related to project size and thus results from rational developer decisions. However, usage seems to be motivated by rather practical than quality concerns, as shown by the predominant use of combined features including self-annotated classes in any size of projects.

A first perspective is to study more precisely how Spring features are combined according to project size or domain. We also plan to compare features from other technologies (languages) and frameworks. A more practical perspective is to pursue the development effort to try and better assist developers in their architecture deployment activities by visualization and development of assistance tools.

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A brief review of corner detection approaches

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Abstract. Corner is one of the important local point of interest having the defined characteristics of robust point of interest and is also an active research area for machine vision researchers. Amongst the different approaches of corner detection, signal processing based corner detection is more robust due to both its accuracy and efficiency. In this approach Harris corner detection algorithm is used for benchmarking as being analytically systematic corner detection. The recent work of anisotropic asymmetric corner detection method has outperformed than all classical corner detection methods. The summary of classical corner detection and anisotropic based corner detection is reported in this paper.

Keywords: point of interest, corner detection, anisotropic filtering.

1 Introduction

For object detection & classification in computer vision, it is very decisive in the primary stage to choose a robust and efficient point of interest for further stages of description & classification [1-2]. The robustness for the point of interest has been defined as having the characteristics of locality, distinctiveness, generality, repeatability and quantity [3]. Furthermore, the efficiency is defined as real-time applicability. Based on the aforementioned properties corner possesses most of the characteristics comparing any other points of interest in an object. That is why, corner is an active research area & as a widely used point of interest and subject to description and classification [4]. Today many computer vision application is based on corner detection such as; object matching and recognition, object tracking, stereo vision and 3D reconstructions [1]. There are many different definition for corner, but all come to the same concept. Corner is point with low self-similarity, or corner is a point having different intensity orientations [5]. Amongst the three general approaches for corner detection that are: template based, geometric based and signal processing based approaches; the signal processing based approach has been evaluated as more robust and efficient. Meanwhile, among the methods of corner detection in signal processing approaches, the anisotropic filtering based approach has shown outperformance as benchmarked with state-of-the-art [6]. As the organization of this summary paper, the next section briefs the literature and the final section presents the conclusion.


2 Literature

Object detection and description involves feature extraction and classification. There are global features and local features for objects. Global feature refers to those features relating to the whole scene of image, such as color information, shape and textures. The advantage of global features in general is performance, but the significant disadvantages of global feature is that it is not robust in general as not being invariant to occlusion, clutter, and image geometric transformations[7]. Local features refers to the features which are local to the image, such as region, blobs, junction and corner. Local features are more robust and remains invariant to occasion, clutter and some image non-photometric transformations [8]. The selection of interest points and feature around has key importance for the classification and recognition of objects [7-8]. Corner and junctions are robust interest points, because of its geometric and intensity properties remain distinctive after transformation. The corner exhibits many intensity orientation as compared to homogeneous region which doesn’t show orientation changes [8]. The orientation in the image can be generally estimated using Hessian matrix, structure tensor, voting tensor and anisotropic filtering [6]. Corner detection approaches can be categorized in three general approaches:

2.1 Template based approach

In this approach mathematical models are created for certain types of corner and junctions (T, L, Y, X …), and then the model is moved and compared across the image, searching for the structures fitting the model [9, 10]. The problem with this approach is that it’s difficult to develop a generalized model and in the case of transformation in the image matrix, as the structure shape changes, the new structure require new models, which in practice makes it less applicable and efficient. The well-known methods developed in this approach is SUSAN [9].

2.2 Geometric based approach

In this approach the curvature along the edge is computed. This approach requires global segmentation, contour chain formation and linking, before the curvature analysis is made. In each step of this approach, there is accumulation of noise & it significantly effects the accuracy of this approach [7]. The well-known method based on this approach is Kitchen Rozenfeld [11]. Kitchen Rozenfeld uses Hessian matrix & K-cosine for the estimation of corner points which is based on second order derivative. As we know that 2nd derivative is suited more for ridge detection rather than corner [14, 15].

2.3 Signal processing based approach

This approach is more robust and more used as compared with two previous approaches and the state of art techniques relates to this approach. The first technique developed with this approach was Moravec corner detection [5,12]. Moravec used a small binary window with 8 orientations. This method was not robust, because of binary
window and only computation of eight orientation which can’t cover many corner types [12, 13]. The prominent method in the scope of this approach is used for benchmarking is Harris & Stephen corner detection. Harris used Gaussian window, and developed the corner detection algorithm with Taylor expansion which is capable of small shift based on requirement and thresholding of corner. Harris corner estimation applies auto-correlation of structure tensor and local maxima is extracted based on maxima and minima of elliptical structure [5]. The recent method of corner detection developed is anisotropic asymmetric filtering which outperformance Harris. This method is the combination of two asymmetric kernel, half Gaussian filter and IRON (Isotropic and Recursive Oriented Network) [6]. IRON is a network of parallel line computing the variance along the length and computing the mean in width, while the half Gaussian filter is produced by Heaviside function of anisotropic Gaussian. Using the anisotropic filtering can only computes (0–π) degree orientation, and not covering all the orientations and that is why it is unable to capture all corner points. Secondly using only the Half Gaussian Kernel (HGK), will be able to precisely find the corner, but there would be false response in homogenous region and false corner points around the edge contour. The combination of two asymmetric kernel HGK and IRON is used to overcome this problem. Here the main aim of using IRON is to decrease the strong response of filter along the edge, because the Gaussian smoothing filter has strong response along edge contour, while the IRON has small response the along the edge. Finally the trade-off of precise corner point selection is based on thresholding of angle between (0–π) [6].

3 Conclusion & future work

In this short paper a brief summary of corner detection approaches and state-of-the-art corner detection techniques have been presented. We had benchmarked asymmetric kernel with Harris corner detection as our starting point. We have planned to design new filter as involving steerable wedge filter and new shape filter of being able to efficiently capture complex type of corner such as curved corner.

References


Second year PhD students
Imprecise classification:
Application to plastic sorting

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Abstract. Besides the ecological issues, recycling of plastics involves economical matters that encourage industrial firms to invest in the field. Part of them have focused on the waste sorting phase by designing optical device able to discriminate on line among plastics categories. For achieving ecological and economical objectives, sorting errors must be minimized to avoid serious recycling problems and significant quality degradation of the final recycled product. Even with the most recent acquisition technologies based on spectra imaging, plastic recognition remains a tough task due to the presence of imprecision and uncertainty, e.g., variability in the measurement due to atmospheric disturbances, ageing of plastics, dark or black coloured materials etc. The enhancement of the recent sorting techniques based on classification algorithms leads to rather good performance results, however for such applications, the remaining errors have serious consequences. This necessity of cautious decision making brings us to consider imprecise classification.

Keywords: Machine Learning · Imprecise Classification · Reliable Classification · Belief Functions · Plastic Separation

Imprecise classification aims at enhancing the reliability of predictions by allowing partial prediction for difficult examples. We define the set of the possible classes as \( \Theta = \{\theta_1, \ldots, \theta_n\} \), \( n \) the number of classes, where each \( \theta_j, j \in \{1, \ldots, n\} \) represents the lowest level of perceptible information in \( \Theta \). For the class to predict \( \theta \), we consider that an imprecise classifier gives a prediction in the form of \( \"\theta \in A, A \subseteq \Theta\" \). Such imprecise prediction, rather than the prediction of a single class \( \theta \in \Theta \), is adapted to the problem of overlapping regions corresponding to different classes in the feature space. As pointed out in [8], this can be a way of pre-selecting a subset of classes, thus, permitting to reduce the size of the classification problem which can subsequently be dealt with by more consistent means in terms of calculation, expert identification, additional analysis. This type of classification primarily concerns sensitive areas for which classification errors have serious consequences. For example, during a medical diagnosis, if a patient with clinical symptoms \{"dripping nose", "fever", "ganglion"\} the diagnoses "flu" or "primary HIV infection" are plausible. Given the
risky consequences of a misdiagnosis in such a case, using a classifier admitting its inability to give an accurate prediction is judicious. In our study the context of the sorting and recycling of plastics leads us to consider the imprecise classification. The sorting phase of the plastics confronts us with two antagonistic constraints. Suppose we have three containers: containers A and B, respectively for plastics A and B and a container R for rejection. The first constraint consists in minimizing the sorting errors (in the containers A and B) in order to obtain the physiochemical properties required for the secondary material A, resp. B. A sorting error would involve an impurity in the mixture and cause compatibility problems. The second constraint consists in minimizing the quantity of rejected material (container R) to maximize the economic return. Indeed, generally finely sorted plastics have greater economic gains.

As noted in [6], imprecise classification was first introduced by the idea of abstention which appeared in the 1970s [1] with the notion of rejection option. However, the partial prediction in the form of set of classes is more recent [4]. More generally, note that the principle of improving the reliability of a prediction to the detriment of its relevance was initially introduced by R. A. Fisher [3] and J. Neyman [5] in statistical inference with the concept of confidence intervals, or regions of confidence in Bayesian statistics, by associating a confidence threshold to the provided set. The idea has been generalized recently to classification problems by the notion of “conformal prediction” in [7].

In the following, we define the properties we expect from an imprecise classifier in our sorting problem in order to best target existing approaches. We believe that the choice of imprecise classifier should be based on the following criteria: i) performance, ii) consideration of class overlap, iii) genericity, iv) flexibility. Regarding i) performance, the evaluation of imprecise classification methods is a complex problem [8] in particular for the definition of loss function for imprecise classes. Thus several measures have been proposed such as the F-measure [2], the utility Discounted accuracy [9] or the p-discounted cost [8]. In practice, performance should be evaluated for a various panel of classification problems with several levels of imperfection. For ii) the information reported on the imperfection of the data, detecting the class overlaps, is more or less elaborated according to the theories deployed, posterior probabilities, imprecise probabilities, belief functions, etc. The third criterion concerns iii) the genericity, the imprecise classifiers that satisfy this criterion are those that are able to adapt existing precise classifiers known for their stability. Any positive evolution of a specific classifier can be beneficial to the imprecise classifier that satisfies this criterion. The last criterion, flexibility, refers to the possibility of adjusting the level of the compromise between the reliability and the relevance of the prediction, by setting the classification algorithm with a parameter. Finally, note that complexity is not part of our essential criteria because the number of classes considered in our sorting problem is restricted, i.e., four classes.

The algorithm that best meets our criteria is the nondeterministic [2]. The latter showed competitive results compared to other approaches of imprecise classifications [9]. The algorithm is also generic and flexible. On the other hand, the
information taken into account comes only from posterior probabilities on the classes of $\Theta$ provided by a standard classifier, i.e., only the uncertainty is taken into account. An example inspired by [9] can clearly illustrate the interest of the imprecise classification: let us suppose that the vector of characteristics $x$ of an object to classify, does not contain any information making it possible to classify it in a binary problem $\theta_1$ against $\theta_2$. A precise classifier will have to choose a class randomly, on the other hand, an imprecise classifier will be able to express its ignorance and predict $\{\theta_1, \theta_2\}$. We generalize the idea to compare imprecise classifiers. Let $\delta : \mathcal{X} \subseteq \mathbb{R}^p \to 2^\mathcal{Y}, p > 2$ be an imprecise classifier, $x \in \mathcal{X}$ a new example and $A = \delta(x)$ the predicted set for $x$ with $A \subseteq \Theta$. $A$ is an optimal prediction for $x$ if predicting any subset smaller than $A$ for $x$ would necessarily lead to a random prediction. If we could directly quantify the probability mass of the sets, instead of deducing it from the elements that contain it, we think we can improve the awareness of data’s imperfections and thus optimize the predictions.

References

Third year PhD students
Enhanced decoding of brain activity underlying working memory load

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In crisis management, operators have to make decisions and take actions under stressful and high-stakes conditions. Decision making involves working memory (WM), which is capacity limited [1]. WM load may correspond to the amount of information actively maintained and manipulated at one time. Meister [2] has shown that individual performance in a crisis management framework varies depending on WM load.

Increased WM load causes a decreased power in the parieto-occipital alpha bandwidth [3,4] and an increased power of theta bandwidth at frontal sites [5] with electroencephalography (EEG) measurements. Thus, an analysis of electrophysiological signals derived from continuous measures during the task is relevant for the detection of WM load.

Revealing physiological signatures of WM load would allow monitoring of operator's cognitive state to predict WM load changes and thus prevent errors [6]. Unfortunately, in operating conditions, analysis techniques must overcome time pressure and signal artefacts, such as motion artefacts. A promising strategy is to use a time-resolved EEG classification [7, 8, 9] because it would improve the accuracy of the WM load assessment. In this study, we aimed to analyze EEG (32-channels) signal to identify WM load variation.

Tests were undertaken in twelve healthy young adults (7 women) who performed a dual-task paradigm. The primary task (visuo-spatial task) was used to modulate participant's WM load whereas performance within the secondary task (detection of an auditory stimulus) was used to assess the WM load level. After preprocessing, EEG data has been analyzed. First, we expect to replicate EEG findings of previous studies. Second, with unsupervised machine learning methods we hope to determine stable clusters by primary task difficulty level and thus obtain robust signatures of the WM load variation.

**Keywords:** working memory load, crisis management, EEG, neural activity, machine learning

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A model based approach to design, organize and monitor dismantling and decommissioning of nuclear facilities

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Abstract. Dismantling and Decommissioning (D&D) involves complex operations requiring the collaboration of a large number of stakeholders from various activities, and has to deal with numerous significant constraints. The CEA is conducting research to better pilot these operations and reduce their costs and timeframes, and to improve overall performance. To this end, many issues remain to be solved, which lead to studying, then implementing in the form of a method with appropriate tools, the principles from systemics and the engineering of complex projects and systems. This method first consists in formalizing and specifying the entire set of requirements to be taken into consideration. Second, based on these requirements, the method will enable the project team to structure, check, and then to demonstrate the coherence and feasibility of the project from both the technological and organizational points of view. Lastly, the method should permit a constant re-evaluation of the D&D strategy and the management of its products, depending on the possible evolution of the D&D projects. Demonstration software is being developed, aiming to provide the functionalities requested for the design, implementation and maintenance of a future enterprise software, which should provide a complete D&D project Digital Mock-Up being interoperable and connected to the tools and databases of the stakeholders' information systems.

Keywords: System, Dismantling, Decommissioning, Nuclear facility, Systemic approach, Model Based Systems Engineering, Information System, Method, Enterprise modeling, Enterprise software, System Modeling.

1 Context and issues

Today, more and more nuclear facilities of various types are reaching their Dismantling and Decommissioning (D&D) phase. Managers must pay particular attention to the design and management of the D&D projects. They have to consider the inherent complexity and history of each nuclear facility, especially because it is difficult to generalize elements to all D&D projects despite significant capitalization and valorization of feedback.

Numerous complexity factors are met in D&D, such as:

- the many activities required to carry out D&D operations;
the many stakeholders involved, and their various roles and responsibilities;
the many and various interactions between these elements;
the significant amount of data, information, and knowledge to handle;
the strict requirements based on a strong risk culture;
the project evolutions that require the models to be flexible and adaptable.

At first, each nuclear facility may have been modified or impacted by incidents during its operation phase, which is often very long. These changes should thus be known and taken into account when designing and performing D&D projects, focusing among other constraints on ensuring safety at all times. In addition, designing a D&D project requests to take into consideration the variety of stakeholders and businesses involved: nuclear physics, nuclear chemistry, mechanics, robotics, nuclear instrumentation, computer science, etc. Indeed, they could express various requirements relating to their field of knowledge but dealing with the other fields. This imposes to improve the collaborative work and exchanges. Moreover, to meet the requirements, a large amount of data from different levels of detail should also be managed all along the D&D project life cycle. To this end, quite a few documents and deliverables of different kinds, involving skills from several businesses, are needed [1][2]. Their creation, provisioning and updating are major stakes for managers. However, the quality and availability of data collected from the different phases of the facility's life cycle (including records, plans, etc.) represent a recurring issue for D&D projects. It is therefore particularly important to define the types of relevant raw data to be collected and traced for D&D projects as early as possible [3].

2 Towards a new method

Therefore, we have adopted Model Based Systems Engineering (MBSE) approach and principles [4][5][6]. The purpose is to propose and promote a new method for D&D project engineering and monitoring, based on a systemic modeling framework and equipped with tools. This must support on the one hand nuclear facility description and characterization with a sufficient level of detail and considering the various data available, and on the other hand project description at a level of detail enabling first to design and to validate it before its deployment, then to monitor and adapt it in real time when it is in progress [7].

The modeling framework takes care about the description of stakeholders’ perspectives, aiming to be understandable and shareable, by guiding them throughout the classical functional, physical, requirements, behavioral and risks management points of view. This framework is based on systemic approach and is designed in order to integrate the D&D existing vocabulary or to emerge when requested a new common vocabulary. This has to be sufficient and unambiguous to support the collaboration between stakeholders and at the same time to take into account both the technical and organizational aspects of D&D projects.
Furthermore, the various models obtained and handled by the stakeholders today are not federated. Current existing standards or methods remain limited when considering various points of view, levels of detail, and modeling languages. Considering this last point for instance, the models are realized always using neither the same modeling language (conventionally denoted Domain Specific Modeling language DSML in MBSE context) nor interoperable languages nor even the same media over time. We may mention the case of the maps, which today are evolving on digital media whose content is not always easily used by another media. Models’ federation is however requested for validation and monitoring, and more broadly for all activities involving decision-making strategies [8]. The goal of the new method is therefore to procure a D&D project “whole model” that is built step by step from the design phase. Especially this results from the federation or composition of current models in each point of view. The framework must permit to manage conceptually and technically this requested interoperability between concepts and DSML in an automatic way. In other words, it must integrate and enable the analysis of the interfaces, dependency relations (both from semantic or pragmatic aspect) and related links between all D&D models. This aims the whole project description to gain on relevance and accuracy when managers want to assess the global safety, security and performance of the project, to test and assess alternatives solutions, to trace the impact of some unforeseen events on the behavior of the whole project, and to validate in part or in whole the project.

3 Progress and prospects

Currently, the proposed method is being studied at CEA [9]. For a given D&D project, it first consists in formalizing and specifying all the requirements to be taken into account to bring the project to a successful end. Secondly, based on these requirements, the method should enable to structure, verify, and validate the project while demonstrating its coherence and feasibility both from a technical and an organizational point of view [10]. Finally, the method should permit a continuous reassessment of the dismantling plans and products (e.g. waste), depending on the possible evolution of projects (new stakeholders, unforeseen events, etc.).

The method, especially thanks to MBSE, enables the construction of a formal representation of a D&D system related to each project. Such a D&D system is defined as “a set of elements of various and heterogeneous nature that interact in order to decommission a nuclear facility”. It implements a set of basic concepts through some points of view, such as:

- functional, to model the activities, processes, resources and roles needed;
- physical, to model the means, tools, techniques, and their interactions during D&D operations;
- behavioral, to model both the various scenarios describing the numerous future project evolutions, and the various configurations and functioning modes of the nuclear facility to be decommissioned;
risk management, to model various events that could occur and to evaluate their impact on the project, on the resources involved and so on;
requirement management, to model and check the entire set of requirements for the D&D project.

First, these concepts and relationships are collected, and syntactically and semantically described in a generic metamodel, which is as timeless as possible, and therefore adapted to various nuclear facilities and compatible with the project evolutions. DSML are defined for each point of view. Project managers will be able to model D&D systems and share their models all along the projects. These DSML must therefore be ergonomic and understandable by experts from various businesses who are not necessarily modeling experts. Finally, modeling patterns, describing elements common to a set of projects, can be made and shared among the stakeholders of several projects; they allow in particular certain reproducibility.

The method is today partially equipped and demo software has been developed, based on use cases to prove the meeting of conceptual, methodological, technical, economic and human challenges identified at the beginning of the project. Results provide features requested to handle the proposed design and monitoring framework, helpful for the design, implementation and maintenance of a future enterprise software. This last tool should provide a complete D&D project Digital Mock-Up being interoperable and connected to the tools and databases of the stakeholders' information systems [11]. This should be particularly useful for the overall management and should catalyze collaborative work in D&D projects.

References

Re-documenting software architecture histories

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1 Introduction

All along its life cycle, a software may be subject to numerous changes that may affect its coherence with its original documentation. For that reason, re-documenting software may become essential for easing the understanding of a software architecture. Moreover, understanding a software architecture is highly valuable in term of reuse, evolution and maintenance capabilities. Another important aspect of software documentation, relates to the way concepts are versioned. Indeed, in many approaches and actual version control systems such as Github, files are versioned in an agnostic manner. This way of versioning allows wider versioning capabilities however, no information can be provided on the nature of the new version, and especially its retro-compatibility with previous software versions. For those reasons, this paper proposes to re-document software architectures (Section 2) and to version them (Section 3) with the help of an architecture description language (ADL), especially tailored for managing and driving software evolution, named Dedal [4,3].

2 Re-documenting software

2.1 Dedal

Dedal is designed to give a representation of the entire life cycle of architectures and a support to handle their evolution. The Specification level represents design decisions. It is composed of abstract component types named roles which define the functional objectives of the future software. The Configuration level captures implementation decisions. It is composed of concrete component classes which are realizations of the roles. The Assembly level describes deployment decisions. It is composed of component instances that define deployment for specific execution contexts.
2.2 Re-documentation process

Figure 1 introduces the process which is followed to re-document software architectures thanks to the Dedal ADL [2]. As is shown in this figure, it is possible to re-document an architecture from an object oriented source code and a description of the software deployment. Then, this description is parsed to generate an EMF-based representation of the description which thus allows a model to model transformation at step 2, to fit Dedal language. Then as the generated Dedal Assembly is very incomplete, the source is analyzed for making it complete. Then from this Assembly and the source code it is possible in step 4 to re-document the Configuration level that correspond to a description of the implementation of the software, based on the observed software deployment. Then in last step, the re-documented Configuration is also used with the source code analysis to re-document the Specification. At the end of this step, the Specification must be as generic as possible so it describe in an abstract manner the Configuration. To do so the source code is analyzed, searching for the most abstract classes that can fit component roles implemented by the component classes from the the Configuration.

Thus this process produces a coherent component-based architecture which documents software and allows to automatically detect loss of coherence and then keeping an up-to-date documentation all along the evolution of software. The next step necessary for a long term evolution support is to define a way for versioning concepts in a non-agnostic manner. This is what is proposed in next section.
3 Versioning architectures

3.1 Traditional versioning

Traditionally, versioning activity produces acyclic directed graphs as it is shown in Figure 2. In those kind of graphs, nodes are the successive versions of code files and edges are derivation relations between nodes. However, despite this traditional versioning methods allows to version any kind of files, it is only based on textual differences. In other words a version is only differentiated from the precedent through textual changes which leads to a totally agnostic version graph. Which implies that the architect cannot be guided in the version release and tagging process. This is why in next subsection, we propose to add semantic to the notion of version.

3.2 Versioning three-leveled component-based architectures

In order to provide semantics to version concept, we propose the concept of substitutable version. This concept gives information about how a new version can be introduced and in which proportions it will affect the existing architecture. The version graph would remain the same but would provide this additional information in the nature of its derivation relations. This is what is shown in Figure 3. This concept make it possible to predict the retro-compatibility of a component in the architecture, an architecture description level in the global 3-leveled Dedal architecture and even a 3-leveled architecture version. This retro-compatibility thus makes it possible to apply previously developed concepts of version propagation [1] among the three Dedal architecture levels in order to guide the architect for preserving architecture coherence.
4 Conclusion and future work

Re-document and version software architectures is necessary for supporting and driving a well evolution when this support has been lost. Thus we propose to use Dedal ADL to do so since it offers several advantages when driving the evolution of software. Another part of this research will consist in re-documenting a project with all its versions that we identified on Github so we might observe drift and erosion of software that could have been avoided if software documentation was up to date.

References

Selecting association rules from imperfect data: a contribution to Lessons Learned processes

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Keywords: Lessons Learned · Knowledge Representation · Multiple Criteria Decision Analysis · Association Rule Mining · Imperfect data · Evidence theory.

1 Introduction

Lessons Learned (LL) processes, enabling to take advantage of past experiences, are of critical interest for organizations to guarantee their decision-making process efficiency. Within the LL framework, our work, based on the analysis of past experiences, focuses on the identification of relevant lessons to support the decisions-making process. This problem is studied in a specific application context: the humanitarian response in emergencies. Considering similar humanitarian projects -referred as missions- carried out by an NGO³, we are interested in the influence of decisions made in a given context on the missions success or failure. The specific features of this application domain -oral tradition, little formalization, regular staff turnover- entail two main difficulties to implement a LL process. The first one concerns the acquisition of information required for the analysis. The second one lies in this data analysis, indeed (i) it is imperfect and (ii) only a reduced set of observations is available (cf. number of past missions).

Within this context, we defined an approach for inferring lessons from the analysis of past experiences. The three-step proposed approach relies on appropriate frameworks and techniques to handle or tackle the challenging issues aforementioned. It is framed on: Knowledge Representation, Multiple-Criteria Decision Analysis (MCDA), Knowledge Discovery, and takes advantage of domain expert interactions.

This synthesis briefly introduces the overall approach: the objective and main techniques are mentioned for each step. We then propose to emphasis the last work conducted in this project about knowledge discovery relying on association rule mining techniques.

2 Overview of the proposed approach

The studied semi-automated LL approach aims at inferring lessons from the analysis of past experiences. In particular, the objective is to relate mission features to their success/failure -assessed according to evaluation criteria.

³ Non-Governmental Organization.
The approach described in Figure 1 is based on three steps and relies on Human-machine collaborations. Note that this approach has been initially designed w.r.t. the challenges arising from our application context. However these limits, in particular imperfect data, are common in real applications, and the theoretical framework defined here remains generic.

**Fig. 1.** Overall schema of the proposed LL approach describing the three main steps.

Step A is devoted to the improvement of data analysis capabilities. The collected data about past missions is weakly structured and expressed in natural language. Therefore, the approach first aims at defining a formalization framework to take advantage of this data and build a repository of machine processable missions. In this work, we adopt a formal representation relying on W3C standards, in particular RDF(S) and OWL specifications. The formal representation presents advantages such as data inference mechanisms for Knowledge Base enrichment, or the ease of reuse of existing KBs. The proposed schema defines concepts and properties to express knowledge about the missions (i.e. facts). This knowledge might be collected through forms to further populate the ontology. Reader will refer to [7] for details.

Step B contributes to the LL process targeting. To ease the identification of relevant teachings in the discovery process in step (C), we propose to identify criteria of interest (focus the search). Working toward search space reduction is legitimate considering: (i) the limited number of observations and hence the need of expert domain to criticize the discovered knowledge; (ii) the highly dimensional search space. We define the criteria of interest as the criteria that, for similar missions, are strongly contributing to their success or failure. To this aim, we take advantage of an MCDA method Electre Tri: (a) to evaluate the overall success of missions and (b) identify the subset of criteria having the larger contribution. We define a procedure within Electre tri to identify this contribution. It depends on expert’s preferences and mission performance on criteria. Technical details are available in [8].

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4 i.e. significant number of properties defining missions, use of external sizeable knowledge database, or consideration of evidential framework in the discovery process.
Step C aims at identifying the features of missions explaining the performance (success/failure) on the criteria of interest. We propose to discover this knowledge in the form of association rules (AR) - implication relationships - that could be interpreted as lessons. The implementation of the rule mining process faces two main challenges: (i) the representation of data imperfection in the database, and (ii) the identification of relevant rules for final user. These limits and the proposed strategy to address them are further developed in the next section.

3 Rule mining from imprecise data

Association rule mining (ARM) is a data mining technique designed to extract interesting patterns in databases [1]. An association rule \( r : X \rightarrow Y \) is defined as an implication between an antecedent and a consequent, being conjunctions of disjoint sets of attributes in a database. A large literature focuses on ARM problem and many algorithms have been defined and extended to handle different data types. Also numerous studies have been devoted to characterize what makes rules interesting, and interestingness measures have been defined to identify strong rules in database, [5, 10].

However, as previously mentioned, our application domain implies to deal with a limited number of observations\(^5\). In this context, all the available information must be considered, including imprecise or incomplete one. While handling data imperfection in real-work application is a key challenge, only few work in the ARM field address it. Regarding ARM problem, in the case of missing and incomplete data, evidence theory appears as an appropriate framework, adopted in [6, 9, 11]. These contributions on ARM with imperfect data using evidential framework have some limitations lying in the imprecision expressions handled, and the identification and selection of imprecise rules being derived.

Thus, to address our problem, we propose to take advantage of the evidence theory while studying a richer modelling enabling a broader range of imprecise values. In addition, we propose to extend these existing works with a selection procedure based on MCDA methods to assess and compare rule relevance w.r.t. several notions\(^6\). Note that few works in the ARM field take advantage of MCDA for rule selection, [2–4], however no work tackles both the problem of ARM with imperfect data and their selection using MCDA. Finally, within the framework of our LL approach, the search space for rules has been initially reduced with the identification of criteria of interest: they correspond to the attributes expected in the rule consequent. Besides, we also propose to consider domain knowledge defined on attribute values to both improve the selection process and to reduce complexity of the mining process.

Thus the strategy to select AR from imperfect data is based on: imprecise or missing data modelling with evidence theory; rule interestingness assessment in this imprecise context; and selection of the most relevant rules using MCDA.

\(^5\) an observation corresponds to the description of a mission w.r.t. a set of attributes (i.e. conjunction of attributes values).

\(^6\) e.g. rule interestingness might be characterized according to several concepts, such as reliability or specificity, and sometimes conflicting.
4 Conclusion and perspectives

This synthesis briefly summarized our work on the definition of a general LL approach to infer teachings from the analysis of past experiences. It is based on three main steps: (A) representation and formalization of past experiences, (B) identification of criteria of interest to focus the LL process, (C) knowledge discovery in the form of association rules. We emphasized our recent work on this last step aiming at selecting relevant association rules from imprecise data. It enriches existing ARM approaches using evidential framework with (i) a richer modelling, (ii) a selection process, and (iii) a restriction based on prior domain knowledge. The proposed approach could be refined considering interaction between interestingness measures, or incorporating additional measures, particularly subjective ones (domain and user dependent). An empirical evaluation of this approach has to be planned. Also, limitations in terms of complexity and efficiency, mainly due to evidential framework, have to be discussed.

To conclude at the scale of the LL approach, at this stage, the main challenge lies in the integration of the three steps. Also, some insights about the overall evaluation of the approach have to be evoked.

References
