Conceptual Architecture of a Multi-Dimensional Modeling Framework for Older Office Workers

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ABSTRACT

There is an alarming rise/increase of older people in EUs population, with an expected percentage of people over 65 at 30% by 2060, and the majority of older workers willing to work past their traditional retirement age. The concept of Work Ability, which has been developed as an important multi-factor concept that can be used to identify workers at risk for an imbalance between health, personal resources and work demands, has the potential to mitigate the decrease in work ability of office workers while aging. The framework for modeling the work ability of the office worker, described at a conceptual level in this work, is grounded in a holistic multidimensional model which accounts for both the cognitive and physical resources of the individual, and factors related to work and the environment outside of work. AI tools for prediction and risk assessment allow for dimension specific decision support and intervention, including on-the-fly flexible work management, coping with stress at work, and on-demand training.

CCS CONCEPTS

• **Information systems → Decision support systems**.

KEYWORDS

healthy ageing, office worker, functional abilities, cognitive capacities, worker-centric artificial intelligence

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1 INTRODUCTION

The alert rhythm of EU population ageing projects expected percentage of people over 65 at 30% by 2060. The majority of older workers indicate that they plan to work past their traditional retirement age, which is due, in part, to the reduced value of the retirement portfolios/income and improved health and consequently increased life expectancy. In 2010, the EU has set an objective to increase by 2 the Healthy Life Years Expectancy (LYE, disability-free) by 2016, by adopting a battery of preventive approaches. However, these approaches have to be adapted to the new realities of the labour market, taking into account that retirement age has been extended far beyond the age of 60 in many EU countries (already set at 67). In many cases older workers work because they want to – because they are highly engaged in their work, satisfied with their jobs, and committed to their organizations [7], or driven by financial reasons (e.g. insurance not covering adequately the cost burden due to health condition). Older workers tend to be engaged and enthusiastic about their work, which is a positive and affective connection that motivates an employee to invest in getting the job done, not just "well" but "with excellence" because the job energizes the person. Engaged employees use less health care, take fewer sick days, are more productive, have longer tenure, and create stronger customer relationships [12]. Although relatively older, the future labour force in Europe will be formally well qualified, as the labour force with high–level qualification (ISCED 5 and more) is projected to increase by more than 15 million in 2025 as compared to 2015, of which more than 56% will be females. Furthermore, while the employment in the primary economy sectors (agriculture, mining, manufacturing, electricity supply, etc.) will drop, the percentage of office workers (ICT services, financial and insurance activities, administrative and support service activities, etc.) will increase [4]. Thus, continuous acquisition of skills and knowledge is highly important for people aged 55+ performing some sort of office work, in order to make sure they are prepared for the higher demand of increased qualifications and the increased job opportunities in these sectors.

On the worker side, the feeling of job satisfaction is reinforced by the feeling of job security, which in turn is directly linked to health status (unemployment leads to higher levels of depression). A positive change in the perceived job security impacts on mental health as measured by self-reporting, respectively one percent change in job security results in a positive 0.22% change in mental health [1].

At the same time, health problems could limit a worker's career development opportunities, leading to high demand/low output employment. Most adults of age 55 to 64 live with one, two or even more chronic conditions: 69.5% of adults of this age group live with 1+ chronic conditions (67.7% of male and 71.1% of female); 37.1% of adults of this age group live with 2+ chronic conditions (32.3% of male and 41.5% of female); and 14.4% of adults of this age group live with 3+ chronic conditions (11.1% of male and 17.4% of female) [10]. Furthermore, in Europe, the prevalence of chronic diseases such as diabetes is rising due to changes in lifestyle (particularly rising obesity) and treatment for chronic diseases is not optimal (e.g. too many people are admitted to hospitals for asthma and COPD) [6]. Furthermore, the lifestyle of office workers is characterized by prolonged sitting and overall sedentary life, which has the potential to significantly and independently of other factor increase the risk of cardiometabolic diseases and premature mortality [11]. Office work also affects functional abilities of the workers [3], [13], and other contextual factors related to the office workspace (e.g illumination, ambient conditioning system) influence office workers' behaviour, comfort and productivity [2], [15]. The design and realization of age-friendly living, recreational and working environments for the older office worker could be informed by the Work Ability concept.

2 BACKGROUND ON WORK ABILITY

The concept of Work Ability has been developed as an important multi-factorial concept that can be used to identify workers at risk for an imbalance between health, personal resources and work demands [14]. The work ability concept is based on the assumption that work ability is determined by an individual's perception of the demands at work and the ability to cope with them, thus it is important to consider when designing/offering age-friendly workplaces. The efficiency of any intervention strategy is highly dependent on the capability of the used Work Ability model and measurement to capture in a holistic, but at the same time personalized, approach. Previous research showed that work ability, measured with the Work Ability Index (WAI) is negatively correlated with older age, high physical work demands, high psychosocial work demands, unhealthy lifestyle and a poor physical fitness [5]. It is also important to promote social support and networks at the workplace and in private life, as well as coping-oriented approach to health issues and other aspects of life in order to strengthen work ability. Furthermore, lower work ability levels have been shown to result in decreased work performance, productivity loss, long-term sickness absence and early exit from work, and there is a strong association between the perceived health status and work ability.
In the past, a number of models have been proposed to model work ability [8], including:

- the balance model which is based on a stress-strain model (occupational stress creates strain within the individual), assuming that it is possible to evaluate how well a person's resources correspond to the demands of work by examining the degree of strain;
- the multidimensional work ability model considers coping at work, having control over one's work and participating in the work community as important dimensions of work ability, which on the individual level signify physical and mental resources, expertise and general social skills, and the skills needed in work life.

However, it is not sufficient to define work ability, but one also have to recognize its level and to assess actions/interventions needed to maintain and promote it. The challenge is to establish adequate tools to evaluate and measure work ability. Previously proposed measures include:

- the work ability estimate which only examines if a person is completely fit for work, partially disabled for work or completely disabled for work;
- the work ability score, based on self-estimation of work ability on a scale from 0 to 10;
- the WAI, based on a series of questions that take into consideration the physical and mental demands of work and the health and resources of the employee.

The WAI has been previously used to assess the work ability of older computer workers, demonstrating capacity to capture the decrease in work ability of office workers while aging . However, previous studies consider questionnaire-based assessments, which cannot be performed continuously to capture the changing and evolving functional and cognitive capacities of the worker in various contexts. As such, it cannot allow for prediction of short- and long-term changes in Work Ability sustainability.

3 THE PROPOSED MODELING FRAMEWORK

The proposed framework for modeling the work ability of the office worker is being implemented as part of the SmartWork system (see Section4). The modelling of the work ability is grounded to the holistic multidimensional model which accounts for both the resources of the individual and factors related to work and working and the environment outside of work. More specifically, the modelling of the Work Ability will be based on:

- personalized patient models derived from integration of the health condition specific patient models (e.g. multiple chronic conditions) and behavioural models,
- personalized emotion and stress models of the office worker,
- personalized cognitive models,
- contextual work tasks modelling,
- work motivation and values

Continuous assessment of the various dimensions of the Work Ability is facilitated through the continuous unobtrusive monitoring of the health, behaviour and emotional status of the office worker. Next, AI tools for prediction and risk assessment will allow for dimension specific decision support and intervention (see Section 5), such as on-the-fly flexible work management (to cope with health management), coping with stress at work, on-demand training, memory training, and behavioural interventions.

4 SMARTWORK SYSTEM AND SERVICES

The SmartWork project builds a Worker-Centric AI System for work ability sustainability, which integrates unobtrusive sensing and modelling of the worker state with a suite of novel services for context and worker-aware adaptive work support. The unobtrusive and pervasive monitoring of health, behaviour, cognitive and

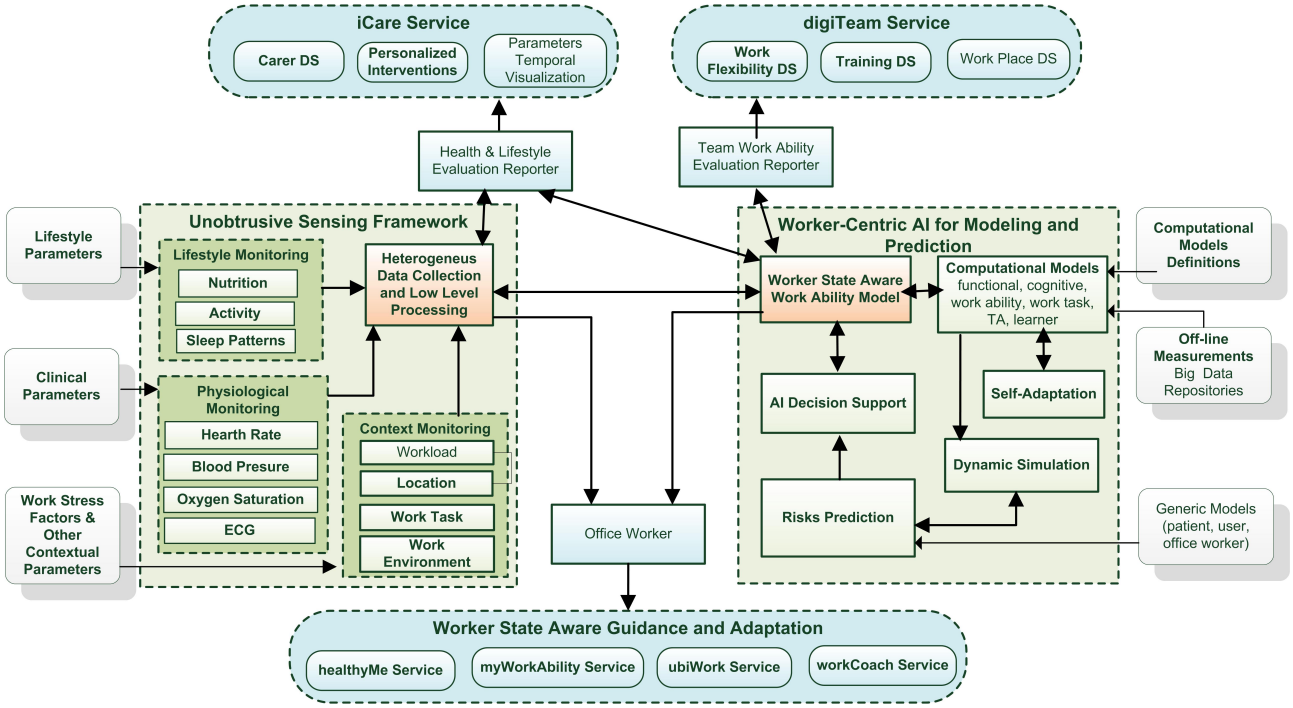

Figure 1: Conceptual architecture of the multi-dimensional modeling framework

emotional status of the worker enables the functional and cognitive decline risk assessment. The holistic approach for work ability modelling captures the attitudes and abilities of the ageing worker and enables decision support for personalized interventions for maintenance/improvement of the work ability. The evolving work requirements are translated into required abilities and capabilities (i.e. work ability model), and the adaptive work environment supports the older office worker with optimized services for on-the-fly work flexibility coordination, seamless transfer of the work environment between different devices and different environments (e.g. at home, at the office, or on the move), and on-demand personalized training. The SmartWork services and modules for on-the-fly work flexibility also empower the employer (manager) with AI decision support tools for efficient task completion and work team optimization through flexible work practices. Formal/informal carers are enabled to continuously monitor the overall health status, behavioural attitudes and risks for the people they care for, and adapt health and lifestyle interventions to the evolving workers status, thus providing full support to the older office workers for sustainable, active and healthy ageing.

4.1 User Groups

The main user groups of SmartWork system and services are identified as follows:

- Older office workers, who will benefit from the User-Centric AI system for multi-dimension work ability sustainability, continuous unobtrusive and pervasive monitoring and risk assessment for their health status and overall functional and cognitive capacity, and provision of context- and worker-aware flexible and adaptive work support
- Employers, including managers and supervisors, who will be able to improve efficiency and productivity of office workers teams through a novel approach, by shifting focus on increased job satisfaction through work flexibility and optimal contextual knowledge management
- Carers, formal and informal, who will be able to continuously monitor the health status of the workers they care for, through automatically extracted higher level of health status and potential short- and long-term risks assessment, and adapt health and behavioural interventions to the evolving worker state.

4.2 Smart Services Suite

The implementation of the Smart Services Suite, integrates and shares on the various dimensions of the Worker State aware Work Ability modelling, a series of transdisciplinary methods and technologies (e.g. functional modelling, cognitive modelling, accessible-born interaction interfaces), to address the needs and requirements of the main user groups.

(1) healthyMe Service: a service for continuous, unobtrusive and ubiquitous monitoring of physiological and behavioural parameters, for efficient self-management of chronic health conditions, positive change of behavioural attitudes and improved quality of life of the older office worker.

(2) myWorkAbility Service: a service for continuous assessment of the psycho-physical capacity of the office worker, provision of flexible working practices, and provision of AI decision support to enhance their psycho-physical capacity by predicting short- and long-term changes in capabilities and abilities of the office worker and translating such changes into evolving work requirements.
(3) ubiWork Service: a service to support on-the-fly work flexibility through an ubiquitous computer work environment.
(4) workCoach Service: a service for on-Demand training support and new skills acquisition to support the older worker prolong his/her functional work ability and increase technology acceptance.
(5) digiTeam Service: a service that allows for smart and flexible management of the workforce from the side of the employers (e.g. manager, supervisor) to increase efficiency and productivity of teams working on specific tasks, and to optimize training and knowledge management activities.
(6) iCare Service: a service for efficient continuous care management and health risk assessment of the people they care for.

5 CONCEPTUAL ARCHITECTURE OF THE MULTI-DIMENSIONAL MODELING FRAMEWORK

SmartWork will develop an integrated framework for the heterogeneous data collection and processing, to enable the AI-driven preventive health care, lifestyle and work-related interventions for the older office workers (see Figure 1). The ultimate goal is to create a feeling of safety for older workers regardless of the location and environment in which they act (office, work or on the move), thus reducing health-related distractions at work, risks and stress or anxiety. In this scope, the functional and cognitive capacities of the older office worker will be modelled in a holistic approach, based on the virtual user concept, and taking into account the potential physical limitations due to health conditions, behavioural parameters, cognitive capacity, and emotion and stress factors. Data heterogeneity will be addressed by developing models, and data encoding and exchange standards for the low level modelling (e.g. disease-specific patient models) and for the integrated modelling approaches (e.g. functional model, cognitive model, Work Ability model), to ensure model reproducibility and sharing. Emphasis will be given in the development of modular approaches to ensure that self-contained models could be developed and validated independently before being incorporated into the higher level models (e.g. Work Ability model). The models will be enhanced with metadata and a semantic layer, to ensure that data elements can be properly interpreted and compared, and to facilitate semantic coherence of the integrated data to allow linking and reuse of knowledge. Advanced data mining and machine learning methods (e.g. deep learning approaches) will be used for pattern identification in heterogeneous data sets of daily living and working, and existing models for chronic conditions self-management (e.g. asthma control monitoring [9]) will be employed to implement the decision support and interventions, with the goal to implement real-world practical and unobtrusive alerting (e.g. prioritize alerting during work tasks implementation). To support decision making, data interpretation will employ novel designed rule induction methods in combination with the identification of important risk factors for the higher level models to automatically extract interpretable rules for Work Ability sustainability.

6 DISCUSSION

The implementation of the proposed framework for multi-parametric modeling of older office workers builds on the advantages of the SmartWork pervasive wearable and embedded sensing technologies which allow for continuous monitoring of various physiological, behavioural and lifestyle parameters. The data collection step involves the collection of data streams (structured and unstructured) from different sources (body area sensing, smart sensing devices at work, home embedded sensing devices, portable devices, etc). The main challenges of this step are (i) the unobtrusiveness and pervasiveness fo the sensing system, and (ii) data security and confidentiality. Data collection is followed by analysis, where advanced data analytics are employed to pre-process the collected data (e.g. complete missing values in time series), extract useful information and combine/convert various data. The main challenge in the analysis step is to handle largely heterogeneous data sets, as inefficient data integration between various system components makes it difficult to perform richer analytical data processing. Such analysis allows to identify patterns, associations and trends within the data, and will employ various artificial intelligence methods (e.g. deep learning for big data processing) and computationally efficient data mining algorithms. The last step concerns the development of short- and long-term predictive models using complexity-efficient machine learning methods, based on the patterns and trends identified in the analysis step. Simulation and risk assessment tools will allow for dimension specific (e.g. health, training) decision support and intervention, including on-the-fly flexible work management, coping with stress at work, and on-demand training of the office workers.

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