

# Active Aging in the Workplace and the Role of Intelligent Technologies

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**Abstract**—The ageing population and shrinking pool of labor is posing a critical threat to sustainable economic capacities of many developed and developing countries. The challenge calls for new aging technologies, particularly AI innovations, to be introduced to enable aging-workforce good health, aging labor market participation, and aging-worker security known as active aging in the workplace. This paper provides a synthetic overview of the current research and application of AI technologies for active aging in the workplace (AAiW). It analyzes the literature in the AAiW context, with a special focus on three dimensions (health, participation and security) under the WHO’s active aging framework. It further examines how the intelligent technologies can help older people stay healthy for longer in the workplace, and organizations better deal with an aging workforce. The findings from the literature are consolidated to provide insights into the factors that hamper active aging, and to identify the measures that enhance health, participation and security of older people in and beyond the workplace with the advancement of intelligent technologies.

**Keywords**-Productive aging; age-friendly workplace; multi-agent systems; human-agent interaction; elderly;

## I. INTRODUCTION

The world is experiencing an unprecedented demographic transformation: ageing population, higher life expectancy, declining fertility rate, growing old-age dependency ratio, and their consequences on workforce—a shrinking pool of labor [1]. Worldwide, the share of population aged 65 and over is growing fast. Between 2015 and 2050, a growth of this age group from 604 million to 1.49 billion (247%) is expected [2].

The demographic challenge increasingly threatens the sustainability of global economic capacities, due to not only the reduced workforce participation as described above, but also the increased social spending on elderly healthcare and social protection. Empirical evidence shows that the intensity of using healthcare services of the public sector grows together with age [3]. And these aging healthcare services are costly. For example the costs attributable to dementia a typical aging-associated disease are estimated reaching US\$604 billion worldwide [4] and US\$159 billion in the US [5] in 2010. The financial burden of social protection for the elderly is also enormous. In Europe, according to an analysis from DG ECFIN (the EC Directorate-General for Economic and Financial Affairs), EU’s social protection expenditures directly associated with age (pensions, retirement benefits,

and other long term costs) will rise to 29% by 2060, and its expenditures on retirement benefits alone are expected to rise to 13% by 2060 [6].

A critical means of mitigating the impact of demographic ageing on society and economy is to promote active aging and other similar concepts (e.g. successful aging and productive aging). However, the conceptualization and interpretation of the term “active aging” is varying throughout the years and contexts. WHO defines the concept of active aging as “the process of optimizing opportunities for health, participation, and security in order to enhance quality of life as people age. It allows people to realize their potential for physical, social, and mental well-being throughout the life course and to participate in society, while providing them with adequate protection, security and care when they need” [7]. Active aging in this definition is built on three pillars mentioned above: participation, health, and security [7]. To assess the level of success in active ageing, the framework in [7] outlines six determinants covering economic, social, physical, personal, behavioral, and health.

Based on the WHO framework in [7], we examine the practices and features of the related literature from a perspective of active aging in the workplace enabled by intelligent technologies. Our focus is on three aspects closely related to aging workforce in the workplace. Corresponding to the three pillars in the WHO framework: 1) aging-workforce health, 2) participation, and 3) security in workplace. Different intelligent technologies and AI innovations are analyzed to show how they can be used to help extend working lives, enhance the employability and adaptability of aging population in the labor market, and better deal with aging workforces in organizations. Our purpose is to cut through the diverse and complex streams of the literature in active aging in the workplace and intelligent technology to provide insights into the factors that hamper active aging in the workplace, and to identify the measures that enhance workplace health, participation and security of older people.

## II. CURRENT RESEARCH AND PRACTICE OF AAiW

The evidence of active aging in the workplace is synthesized in this section to provide a holistic overview of the current literature on the research, good practices, features, and issues in this challenging field of AAiW. Considering

the broad range of topic areas in which the AAiW literature could cover, we focus on three main AAiW areas to organize these literature studies: aging workforce health and well-being at work; labor market participation of the aging population; and organizational protection/security to aging employees. Factors that influence the adoption of active aging in the workplace are identified from these studies to enhance the understanding of the AAiW phenomenon.

#### *A. Aging Workforce Health and Well-being at Work*

Aging and work stress, health, and well-being is one of the important research areas for promoting active aging in the workplace. Scheibe and Zacher [8] conduct theoretical research on aging, and work stress and well-being by integrating the transactional model of stress with research on emotional aging. They find that age can not only impact on stressful tasks encountered by employees, but also indirectly affect employees' reactions to these tasks [8]. In another related study from them, Scheibe and colleagues [9] analyze the link between emotional job demands and occupational well-being. The study indicates that meeting emotional demands may negatively affect employees' well-being with age effects: young and older employees are differently impacted by certain emotional job demands [9]. The findings from these theoretical studies may suggest that age-tailored trainings could be useful for increasing the capability of different age groups, especially aging employees to better manage emotionally challenging job demands for them to effectively mitigate the negative impact on their well-being.

Work stress is commonly considered as one of the key factors influencing occupational well-being, but what is the effect of age on the relationships of work stress and well-being? With a focus on interactive effects of age and job stressors on occupational well-being, the study from Mauno et al. [10] investigates whether age moderates the relationships between job stressors (i.e. job insecurity, workload, workfamily conflict) and self-rated well-being (i.e. workfamily enrichment, life satisfaction, job satisfaction, vigor at work). They find that older employees are more negatively affected by high levels of job insecurity than younger employees, while younger employees are more negatively affected by high workload and work-family conflict. The findings of the study recommend different stress management interventions to older and younger employees [10] for better management of stress.

#### *B. Labor Market Participation of the Aging Population*

The labor market participation rate of older people (aged 55-64) is largely different. In Norway, the rate has reached 71%. In Japan, it is 65%, and 61% in the US [11]. Labor market participation by the aging population is a complex issue related to many personal choices and contextual factors: such as the performance of economy, national legislation,

effectiveness of policies, and possibly different work values, cultures, and traditions [11].

Although older workers' intentions to continue working have been widely observed, older workers still face high difficulties finding late career employments. Schalk and Desmette [12] address the predictors of intention to continue working among older workers. They find that organizational, individual, and social factors influence older workers' intention to continue working. Organizations supportive of older workers could sustain their intention to continue working [12]. Similarly, organizations can also create conditions that make continuing-in-work unattractive. The roles of organizations in stimulating older workers to stay at work longer, and in providing them with opportunities for security are detailed in the next section.

#### *C. Organizational Protection/Security to Aging Employees*

Age management in the workplace is an important method to promote AAiW at the organization level [13]. Rudawska [3] summarized a list of key elements from good practices in age management in Europe. Similar to those identified by Appannah and Biggs [14] above, many of these key elements can also provide mature-aged workers with opportunities to sustain employment and secure their jobs. Organizations and employers can do more to address workplace security needs of their older employees, such as providing diversity in HR practices; supporting an age-friendly environment, and giving older employees opportunities for retention after the normative retirement age, as noted by Schalk and Desmette [12].

### III. INTELLIGENT TECHNOLOGIES FOR ACTIVE AGING

#### *A. Intelligent Technologies for Enhancement in AAiW*

In the work context, examples of the enhancement technology include those such as for enhancing and maintaining the physical, mental, cognitive, or social functioning of aging workers. Health@Work project (<http://www.aal-europe.eu/projects/healthywork/>) is developing a mobile application platform that promotes healthy behavior through small daily inputs, activities and monitoring. It intends to increase occupational health maintenance and well-being especially for older caregiving professionals and office workers. Active@Work (<http://www.aal-europe.eu/projects/activework/>) is a web based solution with a virtual assistant tool to help adult workers continue executing their daily work within the organization. Advanced multi-sensors are provided to monitor each individual health status. The solution incorporates an 'intelligent agent' that assists the user at accomplishing his/her work without compromising health and preventing any other risk derived from fatigue or stress at work.

#### *B. Intelligent Technologies for Prevention*

Sensor technology is a fast-developing area for daily task monitoring and measurement, aiming at for example the

prevention of occupational health problems. Wiedemann et al [15] introduced their application of Kinect sensors in ergonomic-monitoring of office work to reduce the health risk from prolonged sitting in front of computers. Another application of advanced sensor technology for reducing/preventing work stress is the Fit4Work system (<http://www.aal-europe.eu/projects/fit4work/>). This is an easy-to-use and unobtrusive system to support older workers in reducing and managing physical and mental stress resulting from their occupation. It is equipped with sensor-packed wearable device (smart watch/electronic shirt) connected with a smart workplace environment and with external services immersed in the cloud. The Fit4Work services can be retrieved through smartphones.

### C. Intelligent Technologies for Compensation

The work environment should allow older adults to compensate for limitations while enabling them to maximize their use of intact capabilities. Here, technology-driven changes can benefit the aging workforce [16]. Axo-Suit project (<http://www.aal-europe.eu/projects/axo-suit/>) is developing assistive devices that compensate/supplement the strength of elderly persons with feasible exoskeletons in undertaking voluntary work. The full-body personal mobility, reaching, and grasping requirements of elderly persons are specified to allow them to continue managing their daily activities related to voluntary occupation, and to participate in local social activities while preserving their health and providing motivation to remain active and independent.

### D. Productive Aging Beyond the Workplace

As more people retire, it may not always be possible to physically accommodate all of them back in the workplace. Crowdsourcing [17] presents a promising solution for productive aging at people's homes. To the best of our knowledge, there is no commercial crowdsourcing platforms explicitly supporting elderly participation at the moment. Nevertheless, pieces of the puzzle for building an intelligent crowdsourcing platform to harness the knowledge, expertise and effort from the elderly are currently available.

In [18], [19], knowledge representation tools that provide a human interpretable format for representing knowledge and processes which can also be easily interpreted by computer have been proposed. For motivating the elderly to participate in crowdsourcing, works that combine human factors into intelligent agents to such as in [20] can be leveraged. Support for collaboration among older crowdsourcing workers can be achieved through multi-agent organization technologies [21] as well as intelligent interface agents [22], [23], [24]. Trustworthy computing research also provides many useful models to foster trust among the older workers [25], [26], [27], [28], [29], [30], [31]. In addition, intelligent technologies are emerging that can help optimize the quality-time-cost trade-off to improve the productivity of large

crowdsourcing systems [32], [33], [34], [35], [36], [37]. These innovative intelligent technologies, combined with appropriate changes in policies governing the hiring of older workers, hold the key to sustaining socio-economic growth in aging societies.

## IV. CONCLUSIONS

Active aging in the workplace is increasingly seen as a strategy for mitigating the demographic challenge to sustain the economic and societal development. New intelligent technologies, devices and services have huge potential to facilitate older workers actively aging in the workplace. This paper has provided a structured review across three crucial themes of AAIW. Through these themes, the paper presents the current research trend and application status in active aging in the workplace. AI technologies and applications to AAIW are examined over three different categories to show their effects of enhancement, prevention, and compensation functions to enable AAIW. In addition, we also envision how intelligent technologies can help productive aging beyond the workplace. By consolidating literature findings, the paper identifies factors and measures important for active aging in and beyond the workplace facilitated by intelligent technology innovations.

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