



**Faculty of Information and Communication Technology**



**A MULTI-CRITERIA HYBRID RECOMMENDER SYSTEM FOR  
ELDERLY INTERVENTION PLANS TOWARD SUCCESSFUL  
AGEING**

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**Master of Science in Information and Communication Technology**

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**A MULTI-CRITERIA HYBRID RECOMMENDER SYSTEM FOR ELDERLY  
INTERVENTION PLANS TOWARD SUCCESSFUL AGEING**

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**A thesis submitted  
in fulfillment of the requirements for the degree of Master of Science  
in Information and Communication Technology**





**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2021**

## DECLARATION

I declare that this thesis entitle “A Multi-Criteria Hybrid Recommender System for Elderly Intervention Plans toward Successful Ageing” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



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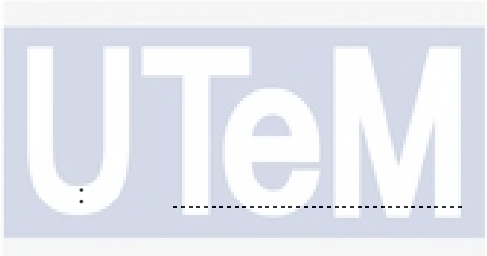

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## APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Information and Communication Technology.



Signature : \_\_\_\_\_

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## DEDICATION

To my beloved parents

my husband and son

my supervisors and lecturers

and also, to all my siblings



## ABSTRACT

Recommender systems are information filtering systems that cope with the issue of excessive data by filtering fragments of important information. The massive amount of information is dynamically generated according to the user's preferences, interests, or observed behaviour of an item. Recommender systems have been widely applied in many domains, such as e-commerce, health, food, and nutrition, movies, and many others. Currently, numerous endeavors have been made to improve the lives of those people who are elderly using recommender systems. Current assessment only focusing on a single assessment process which not comprehensive. The assessment is often used to determine the current and future interventions that should be given accurately to the elderly. To ensure that intervention plans are provided comprehensively to the elderly, many aspects need to be addressed. This research proposes a hybrid recommender system that combines both collaborative filtering (CF) and knowledge-based (KB) approaches based on the profiles of elderly people generated from the elderly assessments. The user profile represents the elderly condition for each aspect of assessments and will be used by the proposed model to recommend interventions for the elderly. The CF was applied for determining similar users based on the profiles of other users. The KB filtering technique was then applied to select the interventions listed by the CF approach based on the interventions given by the experts who participated in this research to improve the well-being of the elderly and helping them to achieve successful ageing. The proposed recommendation model was evaluated based on its accuracy by using precision, recall, and F1 Measure to compare the proposed model with the baseline models using basic search (BS) and CF to determine which recommendation model was preferred in recommending interventions based on multi aspects of successful ageing. The result from the accuracy evaluation using recall, precision, and F1 Measure revealed that the new recommendation model that integrates both CF and KB approach are more accurate compare to baseline model. The Successful Ageing Method (SAM) system that has been developed in this research using this new recommendation model can be used for the elderly institutions under JKM aligned with the Rancangan Malaysia Ke-12 (RMK-12). This will helps the elderly care sector to be better in organizing and taking care of elderly well-being.

## **SISTEM PENGESYORAN HIBRID PELBAGAI KRITERIA UNTUK PELAN INTERVENSI KE ARAH PENENTUAN PENUAAN YANG BERJAYA**

### **ABSTRAK**

*Sistem pengesyoran adalah sistem penyaringan maklumat yang mengatasi masalah data berlebihan dengan menyaring serpihan maklumat penting dari sejumlah besar maklumat yang dihasilkan secara dinamik mengikut pilihan pengguna, minat, atau tingkah laku item yang diperhatikan. Sistem pengesyoran telah banyak digunakan dalam banyak domain seperti e-dagang, kesihatan, makanan dan pemakanan, filem dan lain-lain. Pada masa ini, terdapat banyak usaha yang dilakukan untuk memperbaiki kehidupan orang-orang tua dengan menggunakan sistem pengesyoran. Penilaian semasa hanya menumpukan pada satu proses penilaian yang tidak menyeluruh. Penilaian sering digunakan untuk menentukan intervensi semasa dan masa depan yang harus diberikan dengan tepat kepada orang tua. Untuk memastikan rancangan intervensi diberikan secara komprehensif kepada orang tua, banyak aspek perlu diberi tumpuan. Penyelidikan ini mencadangkan sistem pengesyoran hibrid yang menggabungkan pendekatan penapisan kolaboratif (CF) dan pendekatan berasaskan pengetahuan (KB) berdasarkan profil warga tua yang dihasilkan daripada penilaian warga tua. Profil pengguna mewakili keadaan orang tua untuk setiap aspek penilaian dan akan digunakan oleh model yang dicadangkan untuk mengesyorkan intervensi untuk orang tua. CF digunakan untuk mencari pengguna yang serupa berdasarkan profil pengguna lain. Teknik penyaringan KB kemudian diterapkan untuk memilih intervensi yang disenaraikan oleh pendekatan CF berdasarkan intervensi yang diberikan oleh para pakar untuk meningkatkan kesejahteraan orang tua dan membantu mereka mencapai penuaan yang berjaya. Model cadangan yang dicadangkan telah dinilai berdasarkan ketepatannya dengan menggunakan kaedah mengingat kembali, ketepatan dan ukuran F1. Kaedah penilaian ini digunakan untuk membandingkan model yang dicadangkan dengan model dasar yang menggunakan carian asas (BS) dan penapisan kolaboratif (CF). Perbandingan dilakukan untuk mencari model cadangan mana yang terbaik untuk mencadangkan intervensi berdasarkan pelbagai aspek penuaan yang berjaya. Hasil dari penilaian ketepatan dengan menggunakan kaedah mengingat kembali, ketepatan dan ukuran F1 menunjukkan bahawa model cadangan baru yang menggabungkan pendekatan CF dan KB adalah lebih tepat berbanding dengan model asas lain. Sistem Kaedah Penuaan Berjaya (SAM) yang telah dibangunkan dalam penyelidikan ini dengan menggunakan model cadangan baru ini dapat digunakan untuk institusi warga tua di bawah JKM yang selaras dengan Rancangan Malaysia Ke-12 (RMK-12). Ini akan membantu sektor penjagaan warga tua menjadi lebih baik dalam mengatur dan menjaga kesejahteraan warga tua.*

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Azmi, A.K., Abdullah, N. and Emran, N.A., 2019. A Collaborative Filtering Recommender System Model for Recommending Intervention to Improve Elderly Well-Being. *International Journal of Advances Computer Science and Applications*, 10(6), pp. 131-138.

Azmi, A.K., Abdullah, N. and Emran, N.A., 2020. A Hybrid Knowledge-Based and Collaborative Filtering Recommender System for Recommending Interventions to Improve Elderly Wellbeing. *International Journal of Advanced Trends in Computer Science and Engineering*, 9(4), pp. 4683-4689.

Azmi, A.K., Abdullah, N. and Emran, N.A., 2019. A Recommender System Model for Improving Elderly Well-Being: A Systematic Literature Review. *International Journal of Advances in Soft Computing and Its Applications*, 11(2), pp. 87-108.

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# CHAPTER 1

## INTRODUCTION

### 1.1 Introduction

Nowadays, more than ever before, the elderly play a significant role in society, mainly due to their ability to manage their lives. However, some have difficulty managing themselves due to certain aspects and problems associated with their health and physical well-being. As such, the responsibility for caring for the elderly needs to be well considered, for example, using a recommender system to monitor and manage their well being. A recommender system is a computer application that helps the user to make an important decision regarding which items to choose from based on information that is made available to the user such as products, content and others.

The focus of this study is to propose and evaluate a recommender system model for recommending interventions based on multi-aspects of successful ageing for the elderly. The recommender system employs a hybrid technique that combines both knowledge based and collaborative filtering techniques. As such, a recommendation technique without using rating data can be applied to the recommender system able to focus on multi-aspects.

This chapter is divided into seven (7) sections. The first section presents the motivation for undertaking this research, briefly explaining the chronology of the study in terms of what led the researcher to carry out this study. The second section presents the

problem statements associated with the research, followed by the third section that describes the research questions. The fourth section presents of this study present the research objectives aimed at solving the problems and answer the research questions. The next section addresses the scope of the research, including limitations. The contributions of this study are also described in this chapter.

## **1.2 Research motivation**

In society nowadays, while the economic system in many countries has helped to generate a new era of prosperity for many people, in a number of countries, like Japan and Italy, there is a growing cohort of the community aged over 65 years. Japan is home to the oldest citizenry globally, with 27% of its population at 65 years of age or older (Haider & Faraz, 2017). In 2014, the proportion was around 25.8% of the total population which indicates the number is steadily rising each year. It is predicted that nearly one-third of the Japanese population (32.2%) will be considered senior citizens by 2030. At present, more than one in four people in the country are over the age of 65, while those in the population aged between 15 and 64 years fell by 4% between 2000 and 2010. In Malaysia, the population aged 60 years and above is estimated to be around 1.4 million people and is projected to increase to 3.3 million people in 2020. Due to such increases attributed to the ageing population in these countries, some of the world's largest economies have experienced a sharp increase in healthcare costs, increasing pension costs, and a lessening proportion of citizens in the workforce.

A major contributing factor leading to this trend has also been due to the diminishing fertility rates in these countries over recent decades, further compounded by the longer

lifespan of people. In order to adapt to the increasingly ageing population in these countries, the retirement age has been raised, or pension benefits have been reduced but nevertheless recognizing the need to allocate funds towards caring for the elderly. Moreover, with decreasing population growth and the longevity of people increasing, those aged above 65 now represent the growing share of the world's total population. Though on a positive note, health care treatment has advanced in becoming more effective, thereby enabling people to live much longer. However, in contrast, the elderly are not considered vital to the economic well-being and survival of their households and communities.

Over the next 20 years, the life expectancy of people will increase, which will also impact those who can afford health care treatment. Without receiving adequate care, elderly people will lose their independence. As such, it is quite common for those who work at elderly healthcare institutions to seek recommendations to ensure that the elderly receive suitable treatment or interventions according to their health, physical, social, cognitive, spiritual, nutrition, and environmental aspects associated with their life.

On a global scale, the ageing population is one of the major outcomes of modern society. Nowadays, people are living much longer compared to a century ago, reflecting advancements in medicine, nutrition, and technology. However, ageing poses major challenges as well and will increasingly become a dominant factor moving forward. According to Wahl, Deeg, and Litwin (2016), there are three (3) main components of successful ageing, namely, low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement in social and productive activities. However, a missing component to this three-factor model of successful ageing is positive spirituality, which became the fourth factor proposed by Zimmer, Jagger, Chiu, Ofstedal, Rojo, and Saito (2016) to strengthen the model. Some people consider health and

functions associated with old age as a prerequisite when striving for successful ageing (Cosco, Howse, & Brayne, 2017). Likewise, nutrition and environmental factors are also needed for success ageing (Aleksandrova, Pounis, & Giuseppe, 2019; Costa, Carrion, Puig-Pey, Juarez, & Clave, 2019; Oyeyemi, Kolo, Oyeyemi, & Omotara, 2019). Spirituality nowadays has become more prominent for the elderly to improve their quality of life (Ali, Marhemat, Sara, & Hamid, 2015; Gautam, Neville, & Montayre, 2019).

According to Wahl et al. (2016), Zimmer et al. (2016) and Cosco et al. (2017), in achieving successful ageing, as well as in improving the well-being of the elderly, various aspects need to be considered, such as socialization, health, cognitive, physical, nutrition, spiritual and environment (Ali et al., 2015; Wahl et al., 2016; Zimmer et al., 2016; Cosco et al., 2017; Aleksandrova et al., 2019; Costa et al., 2019; Oyeyemi et al., 2019; Gautam et al., 2019). Those that achieve successful ageing tend to be in good condition regarding all these aspects, having no chronic illness, high levels of resilience, low levels of depression, good social network, and also with high levels of life satisfaction moving into their golden years. Also, elderly people are most likely to age successfully through continuous monitoring and providing interventions for all aspects of their life. Therefore, it can be concluded that many aspects need attention and focus towards achieving successful ageing to improve the well-being of the elderly such as socialization, health, cognitive, physical, environmental, nutrition and spirituality.

Nowadays, most research is centred on improving the well-being of the elderly at home or health care by focusing on guarding and monitoring them using tools, such as CCTV, robots, and other appliance that requires a great deal of cost and neat fixtures to prevent damage. Elderly observations using the recommender system are found to be implemented, but they tend to only focus on aspects associated with nutrition and health,

which is insufficient to achieve successful ageing. A recommender system on health recommendation (Rivero-Rodríguez et al., 2013; Ferretto et al., 2016; Naser et al., 2016; Bocanegra et al., 2017), monitoring of users' nutritional state and food recommendation (Bundasak & Chinnasarn, 2013; Agapito et al., 2016; Jung & Chung, 2016; Ribeiro et al., 2017) are just a few studies and research on the recommender system that helps to improve the well-being of the elderly and to suggest interventions for multiple aspects of successful ageing. Accordingly, this research proposes a recommender system model to help the elderly to achieve successful ageing and to recommend interventions by considering multiple aspects of successful ageing.

### 1.3 Problem statement

Older people often have multiple and complex care needs, so assessing their condition and recommending suitable interventions to them are a highly skilled activities. The assessments on multiple aspects of successful ageing are often used to determine the current and future interventions that should be given accurately to the elderly to make sure they get accurate interventions to improve their well-being. However, the current recommender system approaches for recommending interventions to improve elderly well-being only focusing on a single assessment process which is not comprehensive since it is only focuses on single aspect that contribute to successful ageing. This then will lead to imbalance of elderly daily life. To ensure that intervention plans are provided comprehensively to the elderly, many aspects need to be addressed. Therefore, the recommender system to recommending intervention by considering multi-aspects or criteria is required to improve elderly well-being and help them to aged better. However, the multi-criteria recommender system at present that applies a collaborative filtering (CF) approach

relies on a large number of prior ratings data to make meaningful recommendations. Thus the approach is not suitable for recommending interventions based on multi-aspects of successful ageing because a large number of ratings data are not available in recommending interventions to the elderly. Therefore, a new recommender system model is needed to recommend interventions for the elderly by considering multi-aspects or criteria for successful ageing without requiring a large number of ratings data in making meaningful recommendations.

#### 1.4 Research questions

Based on the problem statement above, there are several research questions that stimulate this study, which are:

- i. How to represent the profiles of elderly users to recommend interventions for elderly people by considering multiple aspects of successful ageing?
- ii. How to recommend interventions based on multiple aspects of successful ageing without requiring ratings data?
- iii. How to evaluate the accuracy of proposed recommender system model?

## 1.5 Research objectives

Motivated by the research problems and the research questions mentioned above, three research objectives are presented:

- i. To create user profiles based on multi-aspects of successful ageing.

This research will create a user profile from the results of the assessment of the elderly based on each aspect of successful ageing. The user profile represents the elderly condition in each aspect and will be used by the proposed model to recommend interventions for the elderly, which are suitable.

- ii. To propose a recommender system model for recommending interventions based on multi-aspects of successful ageing for elderly.

This research will propose a hybrid recommender system model for recommending interventions for the elderly based on user profiles that represent elderly conditions in the multi-aspects of successful ageing. The proposed model will apply collaborative filtering (CF), and knowledge-based (KB) recommender system approaches to provide intervention recommendations that best meet the conditions associated with the elderly.

- iii. To evaluate the accuracy of the proposed recommender system model

This proposed recommender system model will be evaluated in terms of its accuracy by comparing the accuracy with other baseline models by using recall, precision and F1 measure. A recommender system prototype is also developed by applying the proposed model to be used for evaluating the system.