Int. J. Advance Soft Compu. Appl, Vol. 11, No. 2, July 2019
ISSN 2074-8523

A Recommender System Model for Improving Elderly Well-Being : A Systematic Literature Review

Aini Khairani Azmi[1], Noraswaliza Abdullah[1], Nurul Akmar Emran[1]

[1]Faculty of Information and Communication Technology,
Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

email : aini.khairani@yahoo.com, noraswaliza@utem.edu.my, nurulakmar@tem.edu.my

Abstract

Recommender systems are information filtering system that overcomes excess data problems by filtering fragments of important information from massive amount of information that dynamically generated according to user's preferences, interests, or behaviors observed from an item. This paper presents a literature review regarding the recommender system to recommend an intervention to improve the well-being among the elderly. This paper is based on a method of systematic literature review, which is built from massive questions. It appears that numerous endeavors have been taken to improve the lives of those elderly in the findings. However, the efforts are scarce in improving the lives among elderly by using recommender system, as they focused more on a specific aspect such as nutrition and health. Therefore, this paper provides the basis for pursuing research in improving the elderly well-being through a recommender system that considers all aspects of successful ageing which are socialization, health, physical, cognitive, nutrition, spirituality and environment aspect that are essential for optimum well-being among the elderly.

Keywords: *Elderly well-being, Intervention of elderly, Recommender system, Successful Ageing, Systematic Literature Review*

1 Introduction

In today's society, a bullish economic system has produced a new stage of prosperity for many people. Health care has become much more useful and treatment has advanced, thus allowing the elderly to live longer. However, elderly are not so vital to the economic survival of their households and communities as it did in the past. Asia and Europe are two regions where a large number of countries are expected to face mature citizens in the future. In these region, in twenty years, a lot of countries will deal with the situation where the biggest population will be over 65 and average age proximate to 50 years.

Elderly in elderly care is expected to prolong significantly within the next 20 years. Individuals who need treatment will increase accordingly, while the number of individuals who can afford this treatment will reduced. Without receiving adequate care, the elderly have the opportunity to lose their independence. Thereby, it is common for those who works at the Elderly Healthcare to seek recommendations in ensuring that the elderly get their suitable treatment according to their achievement in varied aspects, such as health, physical, social, cognitive, spiritual, nutrition, and environment.

Nowadays, in guarding and monitoring the health of the elderly at home or in the elderly care center of the many appliances used, such as CCTVs, robots, and other appliances that require a lot of cost and good fixes to prevent damage to the equipment. Elderly observations using the recommender system are found to be implemented, but only focus on one aspect such as nutrition and health, which is to improve the well-being of parents, although many other aspects need to be emphasised as well. With this situation, the recommender system that can look into several aspects is suggested in this paper. This systematic literature review analyses and identifies the importance of recommender system for improving the well-being amongst elderly. The outcome of this systematic literature review highlights the significant of recommender system in improving the well-being of elderly. As such, this paper comprises of four sections, where Section 2 describes the review of research method used to construct a systematic literature review, whereas Section 3 presents the result of the review which answering the research questions and this paper is concluded in Section 4.

2 Research Method

In this study, the Kithchenam’s systematic review process was employed [1]. The study of systematic review is divided into three important phases, which are review planning, review conducting and review reporting. There are 2 stages related with review planning which is identification of the need for a review and development of a review protocol. Second phase is review conducting that

consists of few phase which is research identification, primary studies selection, quality assessment study, extraction of data & monitoring and synthesis of data. Last phase is review reporting. It is important to communicate the findings of a systematic review effectively. With a particular end goal, a structured method was implemented as shown in Fig. 1 to perform this systematic literature review in order to inspect the studies that are related to recommender system.

2.1 Research questions and their motivations

The main purpose of this systematic review is to comprehend the recommender system trend which might effectively addressed, the development and evaluation of the recommender system and aspects that could recommender system be tested with. The research questions were aimed on to discover the evidence on the sigificance of recommender system for improving the well-being of elderly as well as their limitations or challenges. The research questions for this systematic literature review are as shown below.

RQ1 What is a recommender system? What are the approaches available and techniques used in the recommender system?

RQ2 In what domains are recommenders applied? Is there any recommender system approach applied to improve the well-being of elderly?

RQ3 What are the current approaches implemented for improving the well-being of elderly? How can the recommender system approach improve the well being of elderly?

Table 1 displays the connection between the research questions and the research motivations.

Table 1 : Research questions and motivations

Research question		Motivation
RQ1	What is a recommender system? What are the approaches available and techniques used in the recommender system?	Discover the definition and the type of recommender system approaches and techniques available.
RQ2	In what domains are recommenders applied? Is there any recommender system approach applied to improve the well-being of elderly?	Discover the domain areas that usually apply the recommender system approaches and investigate any recommender system approach applied to improve well-being of elderly.
RQ3	What are the current approaches implemented for improving the well-being of elderly? How can	Finding out the current approaches employed to improve the well-being of elderly and to investigate how the

	the recommender system approach improve the well-being of elderly?	recommender system approach can improve the well-being of elderly.

2.2 Research Strategies

Upon finishing the research questions, the research process took place. Computerized libraries and databases were combed via search string. A list of the computerized databases were prepared and utilized to search for papers in this study are shown as below:

i. Scopus (scopus.com)
ii. ScienceDirect (sciencedirect.com)
iii. ACM Digital Library (dl.acm.org)
iv. Google Scholar (scholar.google.com)
v. Springer (springer.com)

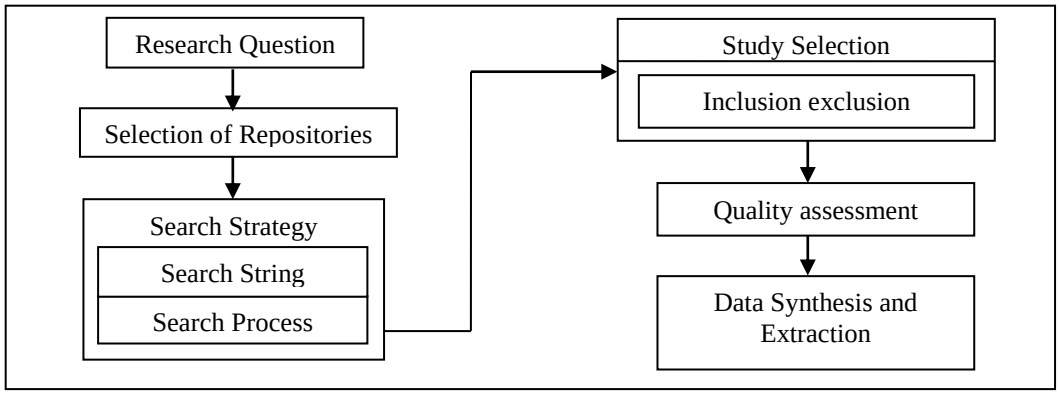

Fig. 1 : Phase of review protocol

The search strings such as (‘recommender systems’, ‘intervention for elderly’ and ‘elderly well being’) were defined based on the research questions and the keywords of the research area. Then the synonyms were brought to lengthen it and the ultimate set of keywords were obtained as shown in Table 2.

Table 2 : Research keywords and synonyms

Keyword	Synonym
Recommender	Recommendation
System	System Software, Technique, Technology, Approach, Engine
Elderly	Old folk, Occupant, Aged, Senior citizen, Older people
Well-being	Welfare, Health, Good health, Happiness, Interest

2.3 Study Selection

In preventing biasness, internal validity and external validity, a quality assessment was conducted following to the identification of relevant papers. Mendeley software package for desktop and online was used in order to accumulate, store and organize the references. The inclusion and exclusion criteria of the papers are identified in the next section.

2.4 Significant Journal Publications in Research

In this study, the search string identified in the previous section has been used in search engines of five computerized libraries and 963 preliminary initial studies have been found as shown in Fig. 2. Due to the diverse filtering settings use in search engine, computerized libraries have returns exclusive numbers of papers. A set of inclusion and exclusion criteria is defined as listed in Table 3 to select a preliminary initial study for further action and to acquire the goals of the review. After a rigorous selection process and duplicate papers were removed, only 66 major studies related to the recommendation system for improving the well-being of the elderly were selected as shown in Table 4.

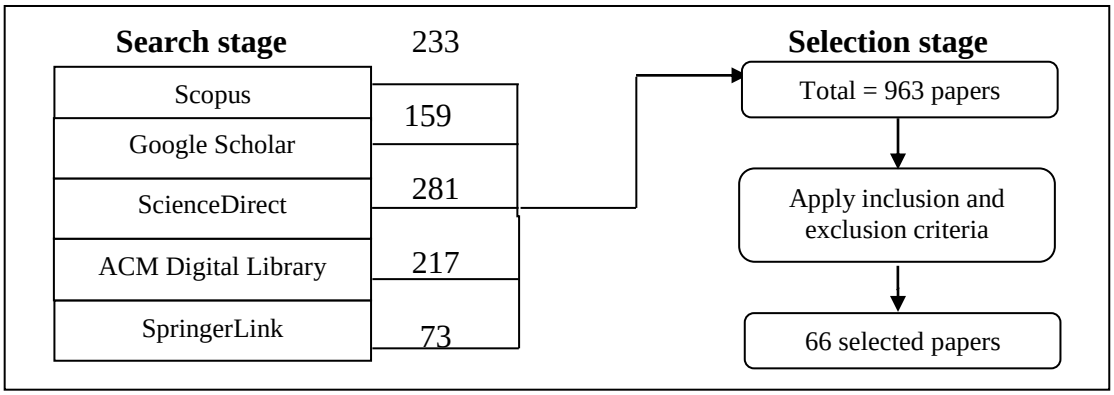

Fig. 2: Search and selection process

Table 3: The inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Publishing language is english	Publishing language is non-english
Paper addressing recommender system	Studies not related to research questions
Paper that report in improving elderly well-being or intervention for elderly	Papers that discuss only abstracts, lack of detail information
Paper published from 2004-2017	Studies that only show tutorials

Table 4: Number of papers after each selection step

Digital source	Search and retrieval	Coarse selection	Detailed selection
Scopus	233	74	49
Google Scholar	159	52	8
ScienceDirect	281	40	4
ACM Digital Library	217	53	3
SpringerLink	73	10	2
Total	**963**	**229**	**66**

2.5 Data Extraction

In the ultimate set of primary selected studies process, extraction of data was carried. Meta-data of paper such as author, title, year, etc were gathered and content data vital to answer the research questions like approaches, techniques and domains of application. Data extraction structure is presented in Table 5. Extracted data is listed in the first column, while clarification for a few of the extracted data which appear vague is provided in the second column and in the last column is the list of research question related to extracted data.

Table 5: Data extraction structure

Extracted Data	Explanation RQ	RQ
Title	Not related	RQ1
Author	Not related	-
Year of Publication	Not related	RQ1
Year of Conference	Not related	-
Volume	Journal volume	-
Source	Digital library from which was retrieved	-
Application domain	Domain in which the study is applied	RQ2
Approach	Recommendation approach applied	RQ3
Contribution	Contribution of the research work	-
Techniques	Techniques used	RQ1

2.6 Distribution of studies per publication year

For this review, 66 major research studies were totally nominated. From these studies, there are 25 journal articles, 35 conference papers, 2 workshop articles, 2 symposium articles and 2 handbook articles classified. The percentages of collated studies are presented in Fig. 3 while total paper issued per year are presented in Fig. 4. The results obtained from selected studies that answered each research question are presented in this section. Various categories of approaches, techniques, hybridization classes, evaluation methodologies and other essential

aspects are classified with instances from the selected studies. The output results are further discussed in the section 3.

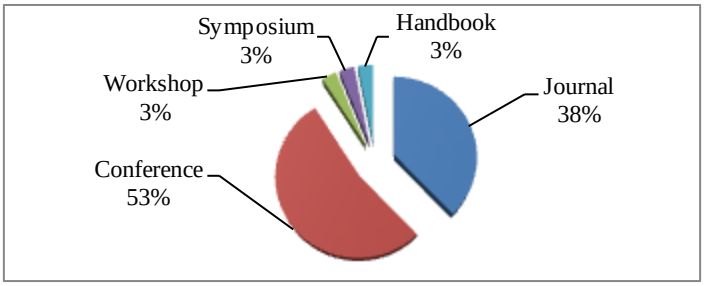

Fig. 3: Percentage of collated studies

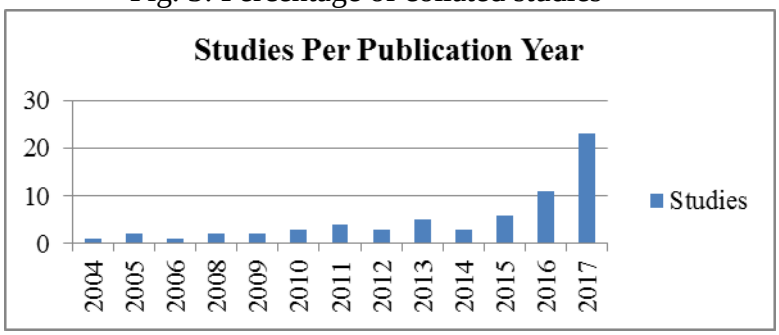

Fig. 4: Distribution of studies per publication year

3 Review Result

The evidence of the related studies is presented in this section. The evidence was based on the previous research articles, journal papers, conference proceedings, and books from other researchers. The period of search for this study is set from 2004 to 2017 since many results related to the recommender system were sought to look into improving the well-being of elderly. The language set for this study was English and the online search was mostly carried out via Scopus. The papers from ScienceDirect, ACM digital library and Scopus databases were accessed via library service available at Universiti Teknikal Malaysia Melaka.

The information from the research papers are collected and analyzed upon the research questions. The references were almost 90% retrieved from Scopus, ScienceDirect, Google Scholar, as well as SpringerLink and ACM digital libraries. The other 10% had been based on books and e-books. The primary data searches for improving elderly well-being were too general and mostly related to improving and monitoring elderly well-being using CCTV and robots for their daily life. Therefore, the search was narrowed to recommender system to recommend interventions for elderly. As such, the three questions that served as

guidelines to discover the literature review pertaining to recommender system to recommend interventions for those elderly as stated in section 2.1.

3.1 Review Based on Research Questions

Research Question 1: What is a recommender system? What are the approaches available and techniques used in the recommender system?

Recommender systems are usually referred to software tools and techniques that provide recommendation for items (general term used to denote what the system recommends to users) to be of used by a user [2]. Suggestions are linked to various decision-making processes, such as what items to purchase, what music to listen to, or what online news to read. Recommender systems act as a significant role in various noticeably rated Internet web sites such as Yahoo, YouTube, Amazon.com, Netflix, TripAdvisor, Last.fm, and IMDb [2]. The recommendation system typically focuses on certain types of items (for example, CDs, or news) and generates suggestions, all tailored to provide useful and effective suggestions for certain types of items, designs, user interface graphs and core recommendation approaches are used appropriately [2]. With the spread of 'big data' on the internet, the recommendation system has gained importance in terms of data clearing and mining. In the early 1990s, information filtering techniques were identified as the need to obtain information more effectively. There are basically four types of recommender system approaches [2]. The overview of description for each recommender system approaches are illustrated in Fig. 5 below.

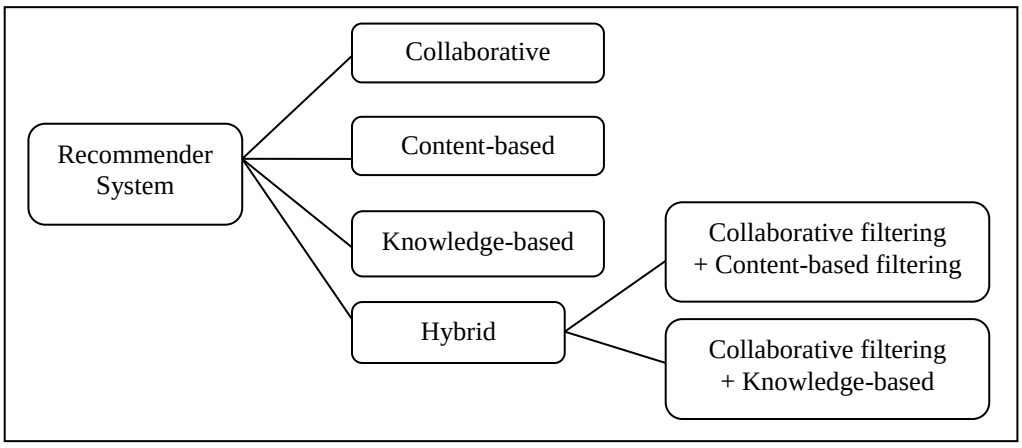

Fig. 5: Overview of recommender system approaches

Collaborative Filtering (CF): It is the most popular technique and widely used in recommender system to generate personalised recommendations. It is based on the knowledge collected and composed from users. The main idea in this approach is to offer recommendations by identifying a subset of users with same interests and preferences. The result from the recommender system may be

diverse based on the purpose of the personalisation that determines usage [13]. One study that employed this approach [19] proposed an algorithm that recommend items to a user by take into consideration the user's current emotion and other users who have same emotion like them. User's emotions are included in the recommender system in this study to recommend appropriate number of neighbours automatically and to choose high-ranking of quality neighbours for predictions on items that the user might be interested. Emotion matrix techniques were used to search neighbours for the current user and to determine appropriate number of neighbours. In the emotion matrix, the rates of the user's mental moods would be stored. Users with similar emotions are found to enhance the performance of the conventional user-based collaborative filtering (UBCF). The result of the experiment showed high recommendation accuracy and offered high quality recommendations.

Content-based Filtering (CBF): It is based on the profile of user preferences and the features of the item [15]. CBF is based on the knowledge assembled from the users and unit descriptions of historic data. In this approach, the similar type of items that the user liked in the past will be found by the recommender system and then the recommendations will be generated. In order to do so, the system, first, have to study key features of the items and users' preferences. To study user's preferences, the recommender system [15] uses several machine learning algorithms, such as Naive Bayes and Decision Producers. An example of content-based filtering is for recommending movies [24]. In using CBF, the system can learn to suggest other movies according to the selected genre to a user if the user has positively rated the movie that belongs to the selected genre.

Another research that used this approach [20] recommended a probabilistic approach for dealing with excessive uncertainty based on TrueSkill for Content-based filtering since it only rely on available items and ratings provided by users. In this research, the Bayesian network model was once proposed for content-based recommendation, and TrueSkill algorithm was adapted to this setting. Item features were assumed to be weights for performance values in TrueSkill and when it was compared to the content-based approach, higher prediction rates were acquired. TrueSkill was proposed for multiple players and teams which allowed to infer players' skills, which are equivalent to user preferences weights in a recommender system setting. In order to tackle the cold start problem, item vector features and learning user preferences were used to sets preferences for every user who have rated the item to learn preferences for every item feature.

Knowledge-based (KB): KB recommends item according to the particular domain knowledge about how the specific item's features comply with users' requirements and preferences, and how the item is useful to users. Constraint-based and case-based recommenders are the basic techniques available in knowledge-based recommender system [25]. Constraint-based recommendation

largely exploits the predetermined reviewer's knowledge base which contains clear rules on how to associate customer requirements with item features whereas recommendations on the basis of similarity metrics can be determined in in case-based recommenders. Some studies have employed this approach. One study [26] recommended the constraint-based recommender system approach by integrating it with a travel advisory system for an Austrian spa resort. In order to tackle the problems of classical algorithms such as content-based filtering and collaborative filtering, this method was used. This research was carried based on a model-driven approach to Web application development where domain specialist and a knowledge engineer would identify the relevant domain knowledge with the support of user-oriented graphical knowledge editing tools.

Hybrid Filtering: Hybrid system is a combination of different approaches or techniques to exploit the advantages of approach A and rectifying the deficiency of approach B. For example, collaborative and content-based filtering approaches were combined in order to overcome the deficiency of collaborative filtering and content-based filtering [17]. In this research, two recommender system techniques are used to model user preferences and past activities. By using the content-based recommender system in this research, short and long-term preferences of the user were exemplify to learn about user's interests and to discover about user's preferences. While collaborative recommender system was used to recommend some news that the user might have not read and involve them in the recommendation process. Emotion data were combined in the recommendation process as context data to offer a positive impact on user's mood implicitly and to enhance the efficiency of the system. The percentages of collated studies approach for recommender system are presented in Fig. 6 and most utilized approaches is presented in Fig. 7. The list of techniques for each approach is tabulated in Table A1 in appendix section.

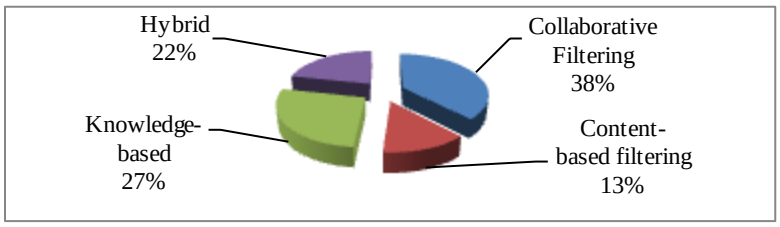

Fig. 6: Percentage of collated studies approaches

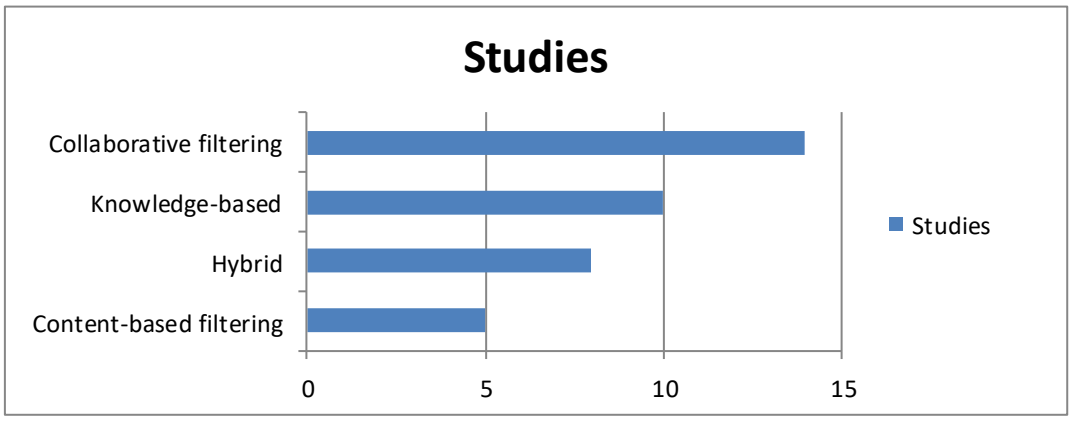

Fig. 7: Most utilized approaches

There are different techniques used by each of the recommender system approach. Two techniques that available in collaborative filtering [9] are memory-based filtering and model-based filtering techniques. There are two ways that can be achieved in memory-based CF ways which is through user-based and item-based techniques. Correlation-based and cosine-based are the most popular similarity measures in memory-based CF. Model-based filtering techniques can be categorized into 8 categories such as association rule, clustering, decision tree, k-nearest neighbor, neural network, link analysis, regression and other heuristic methods.

In obtaining the similarity between documents, content-based filtering uses a variety of models or techniques which are Probabilistic models such as Classroom Waste Classroom, Decision Tree or Vector Space Model such as Frequency Document Frequency (TF / IDF) or Neural Network to produce meaningful recommendations. This technique makes recommendations by learning basic models with statistical analysis or machine learning techniques. For knowledge-based recommender systems, it can be divided into two types which are constraint-based and case-based recommender systems. For hybrid recommender system, there are few type of hybrid RS approach which are weighted hybridization, switching hybridization, cascade hybridization, mixed hybridization, feature-combination, feature-augmentation and meta-level.

In retrieving personalised information on the internet, this recommender system opens new opportunities for it and offer assistance to address the problem of information loads that are a very common phenomenon with information retrieval systems. It also helps to enable users to gain access to products and services that are not promptly accessible to users on the system. To generate a recommendation models, different learning algorithms have been used whereas to measure the quality and performance of the proposed algorithm, the evaluation

metrics have been used. This knowledge empowers researchers and serves as a road map to enhance state-of-the-art recommendation techniques.

Research Question 2: In what domains are recommenders applied? Is there any recommender system approach applied to improve the well-being of elderly?

Recommender system does exist in many types of domains, such as in health, e-Commerce, elderly well-being and many others. The recommender system applied in some domains are presented in Fig. 8 and list of approaches for each domain is tabulated in Table A2 in appendix section.

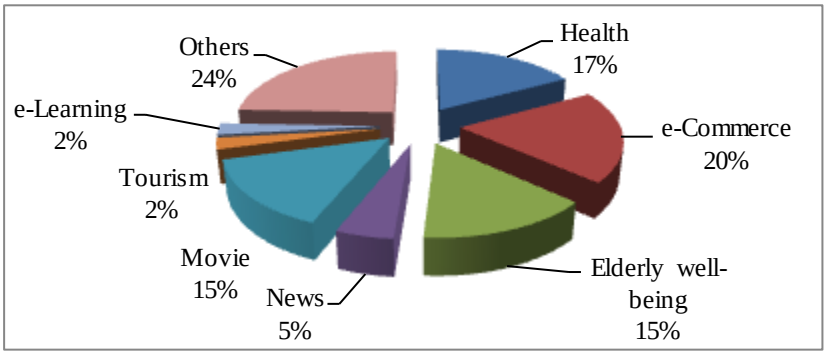

Fig. 8: Percentages of collated studies in RS for some domains

This research study, hence, focused on the domain of elderly well-being. With that, several related studies were collected and studied. The study revealed that, it can be found that, application of recommender system for improving the elderly well-being is scarce. The study also discovered that some recommender system techniques were applied to recommend interventions for elderly to improve their well-being. However, the recommendation of interventions focused on a specific aspect, such as nutrition recommendation [5] which monitoring of users' nutritional state and travel recommendation [48] which recommend travel plan for elderly. This recommender system [5], provided healthy plans of diet for the elderly following expert guidelines which recommending the correct amount of nutrition to an elderly. It retrieved complete and reliable nutritional information from expert sources, such as people for example, nutritionists and gerontologists or computerised for example, information systems, nutritional databases from World Health Organisation and Spanish Society of Parenteral and Enteral Nutrition and users in the context of this recommendations are offered to manage this information.

Another study of recommender system upon the elderly well-being looked into the lifestyle for the elderly so as to which provide support in the context of recommendations to help users cope with typical issues of everyday life and

contributing positively to their welfare [11]. The development of an Ambient Assisted Living (AAL) system called CARE that serves as a test-bed for user studies are focusing on recommendations and interventions. The two potential peer groups of users were recruited. Structured interview among a batch of 20 Greek seniors, and a batch of 27 German seniors, which were formed earlier were conducted. The seniors' life-style, medical needs, attitude towards AAL technologies were focused, and in more specific, on the desired functions and system configurations of a recommendation giving CARE system. The interview's results were discussed and the primary CARE prototype that emerged as an add-on digital image frame that duplicated photo exposure with reserves and interventions, has been drawn to enhance the lifestyle and welfare of seniors. Enhancing the lifestyle of elderly improves their social skills, thus making them happier when talking to others.

Meanwhile, one study proposed demographic recommender system that offered the elderly with information about services from the care, health, recreation, and household areas [8]. The intention of this study was to help the elderly to have a fulfilling life in their own homes and to live longer by providing useful information over one comprehensive source, as well as providing personalised information about the services available around the user. Therefore, the possibility of being integrated into the social environment and the possibility of living independently in the accustomed residence for a longer period will increase. This recommender system is ideal for the issue of demographic filtering as it is strong to huge input vectors that comprise a lot of unrelated information.

Next, another study looked into nutritional semantic recommender system for elderly [5] which allowed the elderly to build their own plan of healthy diet based on their needs due to ageing. Some problems were discovered due to shortage of systems that able to help elderly users in constructing a diet plan by take into consideration on their nutritional needs and tastes preferences, where those preferences were more flexible than only likes or dislikes, but being also inferred from the behavior of users in the system. Some studies also recommend an intervention on menu recommendations for elderly. Complete set of menu meals for an elderly is suggested in this study by using slope one method [13]. This recommender system is able to fix the issue of recommending bundles of well-matching items. In order to predict user behaviour based on other users' behaviour [13], collaborative filtering and slope one predictor approaches were used in this study. This recommendation approach was built based on the weight of the user, in which the recommended food may be preferred or otherwise.

The recommender system for elderly does exist as in prior studies as discussed before. However, the studies only focused on a specific aspect of successful ageing such as nutrition, travel, lifestyle, and social life when in fact, there are many aspects that should be considered and integrated to improve an elderly's

well-being such as health, physical, social, cognitive, spiritual, nutrition, and environment. Interventions should be given to the elderly based on to their performance of all the aspects so that they can achieve successful ageing. Therefore, it is crucial to have a recommender system that can consider all the aspects of successful ageing in order to recommend interventions to improve their well-being.

Research Question 3: What are the current approaches implemented to improve the well-being of elderly? How can the recommender system approach improve well-being of elderly?

In improving the well-being of elderly, monitoring and predicting solutions to an elderly at the homes nowadays are provided by machines and robots. For example, by using a wearable hip assist robot, this device is useful for enhancing function of gait by reducing the muscle effort released by the trunk and lower limbs and by reducing cardiopulmonary metabolic cost while walking in elderly [22]. This device can reduce knee and ankle muscle activities, besides decreasing hip flexor and extensor activity, thus displaying the potential to enhance body stabilization while walking.

Another study found that, in order to detect activities and to assess behavioural trends of an elderly, an automatic monitoring system, which consisted of multi-sensor information of the aged person at home was used in providing different levels of user services. The information was collected in constructing a profile of elderly daily activity patterns for example, use of fridge, meal preparing, sitting on a chair, went for bed [14], in order to analyse their behaviours and to detect changes in their activities. The system can recognize interest events based on the analysis of various-sensors and the recognition of human activities as well as to detect people and keep track of people as they move.

Other research works found, a communication system by using a smart-phone-based robot partner were used to support the well-being of elderly, as well as a web-based avatar [6]. In extracting personal information, the robot partner will be act to communicates according to time-dependent conversation, internet-based information support, and scenario-based conversation. Personal information obtained by the robot partner are routed to the web-based avatar on a regular basis [6], which consists of some information such as hobby, schedule, friend's names, friend's phone numbers, events, illnesses, as well as drug name and consumption schedule. Voice recognition and data analysis are extracted from human personal data through during conversations.

These studies reveal that some works have been done to monitor and support the well-being of elderly especially using machines and robots. However, these

approaches only focused on a specific aspect of successful ageing such as physical. In order to improve elderly well-being to achieve successful ageing, many aspects should be considered, such as health, physical, social, cognitive, spiritual, nutrition, and environment. Hence, there is a need to identify the aspects that could turn into major problems for the elderly, which demand solution and intervention. A recommender system can be applied to recommend interventions for elderly based on their profiles on performance of all those successful ageing aspects. The profile of an elderly performance on each aspect can be gathered from the assessment done on each aspect to the elderly. Then, this profile is used to recommend suitable interventions to the elderly in order to improve their well-being and ensure that they achieve successful ageing.

As such, the hybrid recommender system approach seems suitable to recommend an intervention for the elderly. The hybrid recommender system is better because it incorporates more than one recommendation technique [5] such as by combining the collaborative and content-based filtering approaches. A hybrid recommender system that combines collaborative filtering and knowledge-based approaches is appropriate to propose interventions for the elderly. The knowledge-based recommender system, which uses deep knowledge about the item domain, can be applied to recommend interventions based on the profile of elderly performance on each aspect and interventions needed for each elderly based on the knowledge gathered from the expert domain. After the user profile and the interventions have been accumulated, the collaborative filtering approach can be used to provide interventions recommendations for the elderly based on interventions given for other elderly with similar performance profiles.

The knowledge-based recommendation technique exploits knowledge of the item domain and the user requirements in reasoning what item meets the user requirements. It then recommends items to the user accordingly. It is suitable for recommending interventions for elderly people because their assessment profiles are highly important and are always considered to recommend interventions that are suitable for their conditions. Therefore, a recommender system must take the user assessment result for each aspect into consideration when making interventions recommendation for the elderly. The knowledge-based recommendation technique explicitly asks users about their assessment details and then consults its knowledge-based to recommend interventions that satisfy the elderly's condition. After assessment profiles and interventions for the existing elderly have been determined, the collaborative technique can be used to find a subset of users with similar assessment profiles to a new person and then use this subset for recommending interventions for her or him. Thus, the elderly profiles of the assessments results can be used to recommend interventions for a new person without requiring further evaluation of his or her assessment results.

4 Conclusion

One of the most important areas of healthcare today is ageing. The current system barely keeps up with the healthcare needs of the present aging population, but radical changes are essential to manage the massive demands for care in the coming years. Nowadays, guarding and monitoring while maintaining the elderly and frail population are very complicated and require a lot of expenses. Therefore, in improving elderly well-being, recommender system is one of the solutions that can be used to recommend intervention for those elderly. The recommender system refers to common software tools and techniques which offer recommendation of an item that might be of interest to the target user. However, as for the area of elderly interventions, researches on recommender system to recommend interventions for elderly is still scarce, especially those that consider all aspects of successful ageing. This systematic literature review sheds light on the relevance of recommender system and its significance. The review revealed that the recommender system that recommends intervention for elderly well-being does exist but limited only to specific aspects such as health and nutrition. In addition, most studies for elderly intervention focused on using devices to monitor elderly daily life. In improving the well-being of elderly, many opportunities are presented based on the evidence gathered from this review, such as by recommending interventions based on their conditions on many aspects of successful ageing. On top of that, a recommender system can be developed to cover all aspects needed to achieve successful ageing and to make better interventions for elderly especially towards improving their well-being.

ACKNOWLEDGEMENTS

The authors would like to express sincere appreciation for those who had participated in this research study. The authors of this paper are also appreciative to Department of Information and Communication Technology at Universiti Teknikal Malaysia Melaka (UTeM) in supporting this work.

APPENDIX

This appendix section contains Table A1-A2.

Table A1 : List of research papers according to their technique and approach

Approach	Technique	Reference
Collaborative Filtering	Collaborative filtering and weighted slope one predictor.	[13]
	Group recommendation	[18]
	K-nearest neighbor model	[28, 37, 39, 47, 49]
	Genetic algorithms	[29]
	Rating Distance	[31]
	Asymmetric user similarity and matrix	[19, 32, 45]

	factorization	
	Data mining	[46]
	Neural network and decision tree	[43]
Content - Based Filtering	k-DNF rule with decision list based classification	[15]
	Bayesian network model	[20]
	Multiattribute networks	[34]
	Semantic based	[41, 48]
Knowledge-Based	Case-based technique	[16, 23]
	Constraint-based technique	[21, 25-27, 33]
	Rule-based technique	[7, 11, 44]
Hybrid	Collaborative and Content based filtering	[12, 17, 38, 40]
	Collaborative and Knowledge based filtering	[30, 35-36, 42]

Table A2 : List of recommender system applied based on domain

Domain	**Approach**	**References**
Health	Hybrid recommender system	[12, 42]
	Web-based / Novel recommender system	[4]
	Semantic Content-Based Filtering	[41]
	Collaborative-Based recommender system	[43]
	Knowledge-Based recommender system	[33, 44]
e-Commerce	Collaborative-Based recommender system	[45-47]
	Demographic filtering recommender system	[10]
	Knowledge-Based recommender system	[21, 23, 25]
	Hybrid recommender sytem (CBand CF)	[40]
Elderly well-being	Demographic filtering recommender system	[8]
	Collaborative Filtering recommender system	[13]
	Rule-based recommender system	[7, 11]
	Semantic recommender system	[5, 48]
News	Collaborative Filtering recommender system	[28]
	Hybrid recommender sytem (CBand CF)	[38]
Movie	Collaborative Filtering recommender system	[15, 29, 31-32]
	Content-Based Filtering recommender system	[20, 34]
Others	Collaborative Filtering recommender system	[18, 19, 37, 39, 49]
	Knowledge-based recommender system	[16, 27]
	Hybrid recommender sytem	[17, 30, 36]
Tourism	Knowledge-based recommender system	[26]
e-Learning	Knowledge-based recommender system	[35]

References

[1] B. Kitchenham. (2004). Procedures for performing systematic reviews. Keele, UK, Keele University, 33(2004), 1-26.

[2] F. Ricci, L. Rokach, B. Shapira and P.B Kantor. (2011). Introduction to Recommender Systems Handbook (pp.257-297). Springer, Berlin.

[3] E. Sezgin and S. Ozkan. (2013,November). A systematic literature review on Health Recommender Systems. In *E-Health and Bioengineering-EHB, 2013. Fourth International Conference on* (pp. 1–4). IEEE.

[4] G. Agapito et al. (2016, October). DIETOS: A recommender system for adaptive diet monitoring and personalized food suggestion. In *Wireless and Mobile Computing, Networking and Communications (WiMob), 2016. Proceedings. 12th International Conference on* (pp. 1-8). IEEE.

[5] V. Espín, M. V. Hurtado, and M. Noguera. (2016). Nutrition for Elder Care: A nutritional semantic recommender system for the elderly. *Expert System, 33*(2), 201–210.

[6] B. Yusuf, J. Woo, J. Botzheim, N. Kubota, and B. Tudjarov. (2016, May). Robot Partner Technology Based on Information Support System for Elderly People and Their Family. In *Measurement Control and Sensor Network (CMCSN). Third International Conference on* (pp. 32-35). IEEE.

[7] T. Rist, A. Seiderer, S. Hammer, M. Mayr, and E. Andre. (2015, May). CARE - Extending a Digital Picture Frame with a Recommender Mode to Enhance Well-Being of Elderly People. In *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2015 9th International Conference on* (pp. 112-120). IEEE.

[8] C. Stiller, F. Roß, and C. Ament. (2010, October). Demographic recommendations for WEITBLICK, an assistance system for elderly. In *Communications and Information Technologies (ISCIT), 2010 International Symposium on* (pp. 406-411). IEEE.

[9] F. O. Isinkaye, Y. O. Folajimi, and B. A. Ojokoh. (2015). Recommendation systems: Principles, methods and evaluation. *Egyptian Informatics Journal*, *16*(3), 261-273.

[10] D. Fijalkowski and R. Zatoka. (2011, September). An architecture of a web recommender system using social network user profiles for e-commerce. In *Computer Science and Information Systems (FedCSIS), 2011 Federated Conference on* (pp. 287-290). IEEE.

[11] S. Hammer et al. (2015, July). Design of a lifestyle recommender system for the elderly: Requirement Gatherings in Germany and Greece. In *Proceedings*

of the 8th ACM International Conference on PErvasive Technologies Related to Assistive Environments (p. 80). ACM.

[12] L. R. Ferretto, C. R. Cervi, and A. C. B. de Marchi. (2017, June). Recommender systems in mobile apps for health a systematic review. In *Information Systems and Technologies (CISTI), 2017 12th Iberian Conference on* (pp. 1-6). IEEE.

[13] S. Bundasak and K. Chinnasarn. (2013, May). EMenu recommender system using collaborative filtering and Slope One Predictor. In *Computer Science and Software Engineering (JCSSE), 2013 10th International Joint Conference on* (pp. 37-42). IEEE.

[14] N. Zouba et al. (2009, July). Assessing computer systems for monitoring elderly people living at home. In *Proceedings of the 19th IAGG World Congress of Gerontology and Geriatrics, Paris, France* (pp. 5-9).

[15] A. Pujahari and V. Padmanabhan. (2014, December). An approach to content based recommender systems using decision list based classification with k-DNF rule set. In *Information Technology (ICIT), 2014 International Conference on* (pp. 260-263). IEEE.

[16] X. Li and T. Murata. (2010, October). Customizing knowledge-based recommender system by tracking analysis of user behavior. In *Industrial Engineering and Engineering Management (IE&EM), 2010 IEEE 17Th International Conference on* (pp. 65-69). IEEE.

[17] A. H. Parizi. (2015, April). Emotional News Recommender System. In *Cognitive Science (ICCS), 2015 Sixth International Conference on* (pp. 37-41). IEEE.

[18] A. Pujahari and V. Padmanabhan. (2015, December). Group Recommender Systems: Combining User-User and Item-Item Collaborative Filtering Techniques. In *Information Technology (ICIT), 2015 International Conference on* (pp. 148-152). IEEE.

[19] S. Lazemi. (2016, October). Improving Collaborative Recommender Systems via Emotional Features. In *Application of Information and Communication Technologies (AICT), 2016 IEEE 10th International Conference on* (pp. 1-5). IEEE.

[20] L. C. Quispe and J. E. O. Luna. (2015, October). A content-based recommendation system using TrueSkill. In *Artificial Intelligence (MICAI), 2015 Fourteenth Mexican International Conference on* (pp. 203-207). IEEE.

[21] A. Felfernig and R. Burke. (2008, August). Constraint-Based Recommender Systems: Technologies And Research Issues. In *Proceedings of the 10th international conference on Electronic commerce* (p. 3). ACM.

[22] H. J. Lee et al. (2017). A Wearable Hip Assist Robot Can Improve Gait Function and Cardiopulmonary Metabolic Efficiency in Elderly Adults *IEEE Trans Neural Syst Rehabil Eng*, *25*(9), 1549-1557.

[23] F. Lorenzi and F. Ricci. (2013). Case-based recommender systems: A unifying view. In *Intelligent Techniques for Web Personalization* (pp. 89-113). Springer, Berlin, Heidelberg.

[24] M. Uluyagmur and E. Tayfur. (2012, October). Content-based movie recommendation using different feature sets. In *Proceedings of the World Congress on Engineering and Computer Science* (Vol. 1, pp. 17-24).

[24] A. Felfernig, G. E. Friedrich, D. Jannach, and M. Zanker. (2011). Developing Constraint-based Recommenders. In *Recommender systems handbook* (pp. 187-215). Springer, Boston, MA.

[25] D. Jannach, M. Zanker, and M. Fuchs. (2009). Constraint-Based Recommendation in Tourism: A Multiperspective Case Study. In *Information Technology & Tourism*, *11*(2), 139-155.

[26] A. Felfernig. (2016). Application of constraint-based technologies in financial services recommendation. CEUR Workshop.

[27] D. A. Adeniyi, Z. Wei, and Y. Yang. (2017). Personalised news filtering and recommendation system using Chi-square statistics-based K-nearest neighbour (χ2SB-KNN) model. *Enterprise Information Systems*, *11*(9), 1283-1316.

[28] B. Alhijawi and Y. Kilani. (2016, June). Using genetic algorithms for measuring the similarity values between users in collaborative filtering recommender systems. In *Computer and Information Science (ICIS), 2016 IEEE/ACIS 15th International Conference on* (pp. 1-6). IEEE.

[30] S. Huang et al. (2015). A Hybrid Multigroup Coclustering Recommendation Framework Based on Information Fusion. *ACM Transactions on Intelligent Systems and Technology (TIST), 6*(2), 27.

[31] T. A. O. Jun and Z. Ning. (2017, January). Collaborative Filtering Algorithm Based on Rating Distance. In *Ubiquitous Information Management and Communication, 2017. Proceedings. 11th International Conference on* (p. 66). ACM.

[32] R. Katarya and O. P. Verma. (2016, April). Effective collaborative movie recommender system using asymmetric user similarity and matrix factorization. In *Computing, Communication and Automation (ICCCA), 2016 International Conference on* (pp. 71-75). IEEE.

[33] K. R. Pawar, T. Ghorpade, and R. Shedge. (2016, September). Constraint based recipe recommendation using forward checking algorithm. In *Advances in Computing, Communications and Informatics (ICACCI), 2016 International Conference on* (pp. 1474-1478). IEEE.

[34] J. Son and S. B. Kim. (2017). Content-based filtering for recommendation systems using multiattribute networks. *Expert Systems with Applications, 89*, 404-412.

[35] J. K. Tarus, Z. Niu, and A. Yousif. (2017). A hybrid knowledge-based recommender system for e-learning based on ontology and sequential pattern mining. *Future Generation Computer Systems, 72*, 37-48.

[36] S. Tyagi and K. K. Bharadwaj. (2014). A hybrid knowledge-based approach to collaborative filtering for improved recommendations. *International Journal of Knowledge-based and Intelligent Engineering Systems, 18*(2), 121-133.

[37] V. B. Vaghela and H. H. Pathak. (2017). Optimization of the Neighbor Parameter of k-Nearest Neighbor Algorithm for Collaborative Filtering. In *Proceedings of International Conference on Communication and Networks* (pp. 87-93). Springer, Singapore.

[38] H. Wang, P. Zhang, T. Lu, H. Gu, and N. Gu. (2017, April). Hybrid Recommendation Model Based on Incremental Collaborative Filtering and Content- based Algorithms. In *Computer Supported Cooperative Work in Design (CSCWD), 2017 IEEE 21st International Conference on* (pp. 337-342). IEEE.

[39] V. Subramaniyaswamy and R. Logesh. (2017). Adaptive KNN based Recommender System through Mining of User Preferences. *Wireless Personal Communications, 97*(2), 2229-2247.

[40] S. Pandya, J. Shah, N. Joshi, H. Ghayvat, S. C. Mukhopadhyay, and M. H. Yap. (2016, November). A novel hybrid based recommendation system based on clustering and association mining. In *Sensing Technology (ICST), 2016 10th International Conference on* (pp. 1-6). IEEE.

[41] C. L. Sanchez Bocanegra, J. L. Sevillano Ramos, C. Rizo, A. Civit, and L. Fernandez-Luque. (2017). HealthRecSys: A semantic content-based recommender system to complement health videos. *BMC medical informatics and decision making, 17*(1), 63.

[42] H. Jung and K. Chung. (2016). Knowledge-based dietary nutrition recommendation for obese management. *Information Technology and Management, 17*(1), 29-42.

[43] P. Patil, and S. Gore. (2016). Study of Recommendation System for Yoga and Raga for Personalized Health based on Constitution (Prakriti). *International Journal of Computer Applications, 136*(4), 25-27.

[44] N. Suksom and M. Buranarach. (2010, November). A knowledge-based framework for development of personalized food recommender system. In *Proc. of the 5th Int. Conf. on Knowledge, Information and Creativity Support Systems.*

[45] J. A. Pereira. (2017, May). A collaborative-based recommender system for configuration of extended product lines. In *Software Engineering Companion (ICSE-C), 2017 IEEE/ACM 39th International Conference on* (pp. 445-448). IEEE.

[46] X. . Zhao and K. . Ji. (2013, April). Tourism e-commerce recommender system based on web data mining. In *Computer Science & Education (ICCSE), 2013 8th International Conference on* (pp. 1485-1488). IEEE.

[47] J. Wu, L. Ping, H. Wang, Z. Lin, and Q. Zhang. (2008, December). Research on improved collaborative filtering-based Mobile E-Commerce Personalized Recommender System. In *2008 International Conference on MultiMedia and Information Technology* (pp. 143-146). IEEE.

[48] B. Batouche, D. Nicolas, H. Ayed, and D. Khadraoui. (2012, November). Recommendation of travelling plan for elderly people according to their abilities and preferences. In *Computational Aspects of Social Networks (CASoN), 2012 Fourth International Conference on* (pp. 327-332). IEEE.

[49] P. Adibi and B. T. Ladani. (2013, May). A collaborative filtering recommender system based on user's time pattern activity. In *Information and Knowledge Technology (IKT), 2013 5th Conference on* (pp. 252-257). IEEE.