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A HYBRID RECOMMENDER SYSTEM FOR INFORMATION BROKERING WITHIN WEITBLICK

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ABSTRACT

With this paper the concept for individualised information brokering within WEITBLICK, an assistance system developed in a public founded research project, is introduced. The aim of the project WEITBLICK is to enable elderly people to a longer self-fulfilling life in their own homes by providing information about health, care and leisure activities over one comprehensive source. To filter the large amount of information and services to the needs of the user, a recommender system will be used. The design of the recommender system follows a three tier structure: A tier for candiate preparation selects appropriate items according to the users wish. The second tier generates single recommendation results with different recommender approaches. Thereby the short term context information of tier 1 are rated according to the long lerm preferences of the user. Finally a third tier combines the results from the second tier to a single recommendation result by utilizing the stacking method.

Index Terms— Recommender Systems, Personalization, Machine Learning

1. INTRODUCTION

Caused by the interaction of several effects like the omnipresence and improved ease of use of technologic devices and the increasing consequences of the demographic change, new fields of research and developement emerged in the last years. The efforts in this new and very active area are commonly united under the name Ambient Assisted Living (AAL).

AAL systems are found in different settings. Some originated from home automatisation, others have a health and care related background. Furthermore the addressed user groups range from the "younger olds" who are interested in lifestyle functionality up to multimorbid people whose life still should be as independent and fulfilled as possible. All approaches have in common that they utilize modern technology while hiding the complex technological concepts from the user – thus being "ambient."

The ambition of the system developed in WEITBLICK (Wissensbasierte Technologien und bedarfsgerechte Leistungen für Senioren durch individualisierte Care-Konzepte) is to assist elderly people staying in touch with their social environment and thus allow a longer self-determined life in the familiar neighborhood. To achieve this goal, the system provides helpful, personalized information about services from areas like care and health, recreation or household.

The aim of this paper is to show how such personalized information is provided to the user of the WEITBLICK system using a 3-tier recommender engine. This recommender is able to take the user's short term context as well as long term profiles into consideration.

The remaining part of this paper is organized as follows: The next section introduces the WEITBLICK system, which is the target application for the works presented in this paper. Afterwards aspects of personalization of IT systems are discussed in Section 3. The main part of this work is Section 4, which presents the concept of content personalization within WEITBLICK. Afterwards, the paper ends with an outlook on future works in Section 5 and a conclusion in Section 6.

2. WEITBLICK

In Germany, as well as in other European countries, ongoing changes in the demographic structure of the society cause new challenges especially for elderly people. While traditional family structures are breaking up, people are getting older and concurrently have a stronger need for an active lifestyle [1]. Such a lifestyle can only be maintained, if the contact to the social environment stays active. In many cases, missing information can cause a breakup of this contact.

The aim of the project WEITBLICK is to enable elderly people to live a self-determined, fulfilling life in their own homes for a longer time by providing helpful, otherwise not accessible information over one comprehensive source [2]. The information provided by the system include a wide area of everyday live topicss,

for instance care and health services, bureaucratic help, housekeeping services, community activites, leisure and recreational activities, transport services etc.

Based on the current context of the user as well as his more invariable preferences and tastes, for each user a different part of the available information is relevant. Both aspects have to be considered when trying to find adequate help.

Most of the examples of services listed above are services which either require personal presence of the user or services that only operate within a certain area. When a system like WEITBLICK is only operating for users from a small area, like a single town and some adjacent villages, this might not become a serious problem. But as soon as users from different and distant muncipalities have to be considered, different aspects have to be taken into account. For instance, a bakers shop will most likely only be relevant for people living nearby, while a concert or theatre play is also interesting for users living further away. Also, shops in a larger city or within a shopping district are more attractive than shops in small towns or remote locations. Thus location and geographical relation are considered as valueable information for the WEITBLICK system.

Another concept to be integrated within WEITBLICK, but not discussed in detail in this paper, is the independence from communication channels and devices. If possible, the functionality of WEITBLICK should be accessible with the already existing communication channels and device handling concepts already known to user. If for instance the user is not willing to learn the handling of any technical device at all, some information might still be provided by care personal. Of course, not all functionality will be available on all devices, but a benefit will be available for all users of the WEITBLICK system anyhow.

3. PERSONALIZATION

Personalization of information technology systems has become a more and more important research area, not only in academic research. This is caused amongst other things by the more and more important role of IT in everyone's live. But also the enormous amount of available information, especially in the internet, became too tremendous for most users. The aim of personalization is to compensate both aspects: On one hand, adaptable and thus more user-friendly devices and interfaces open the access to an even wider group of users. On the other hand, personalized content reduces the amount of time needed to find relevant facts within an apperently unmanageable amount of information.

Personalization of information largely depends on how well a system can judge what information is usefull for a user and which part of the information can be left out. The decision whether a information is usefull or not or which of two information is more usefull depends on a large set of pre-conditions. The knowledge, experience, preference, and taste of a human influence this decision in a similar amount as the current context, his aim, and the available choices. The challenge of information personalization systems is to identify the significant pre-conditions influencing the above mentioned decision between helpfull and not helpfull information.

4. RECOMMENDER SYSTEM

For the personalization of information as described in the previous section a recommender system will be utilized in WEITBLICK. Recommender systems are used widely to predict the most useful items out of a set of items according to the user's interests, needs and (especially in newer research work) the current context. Formally, they predict the rating based on knowledge about the users U, the items I, and the previous ratings R, the users gave to the items

$$\hat{r}(u, i) = f(U, I, R) \tag{1}$$

and present the items with the highest predicted ratings $\hat{r}(u, i)$ to the user. Depending on whether similarities between items or similarities between the ratings of users are the determining factor of the prediction, content-based and collaborative recommender systems are distinguished. For an overview on recommender systems see for instance [3].

As mentioned in section 2, in WEITBLICK, the items to be evaluated by the recommender system consist of a wide range of service offers. To adapt the presented results to the current (i.e. short term) needs of the user, while concurrently considering the interest profile (i.e. long term) information, the architecture shown in Fig. 1 is used. The remainder of this section presents the functionality of each of the three tiers presented in this architecture.

4.1. Candidate Preparation

Within the first tier of the WEITBLICK recommender, the adaption to the user's short term wishes is conducted. The output of the tier is a list of all possible candidate items without any ordering or rating. The WEITBLICK user interface offers possibilities to set filters regarding content, time and location of the searched item. Content constraints are set by browsing in a category tree, which gets more and more specific as further down the user navigates. The items in the WEITBLICK recommender are tagged with one or more categories from that tree. If a item is not in the category selected by the user or a subcategory of it, it is removed from the candidate list.

Filtering of time and location can be optionally set by the user. Services, which do not fit these additional

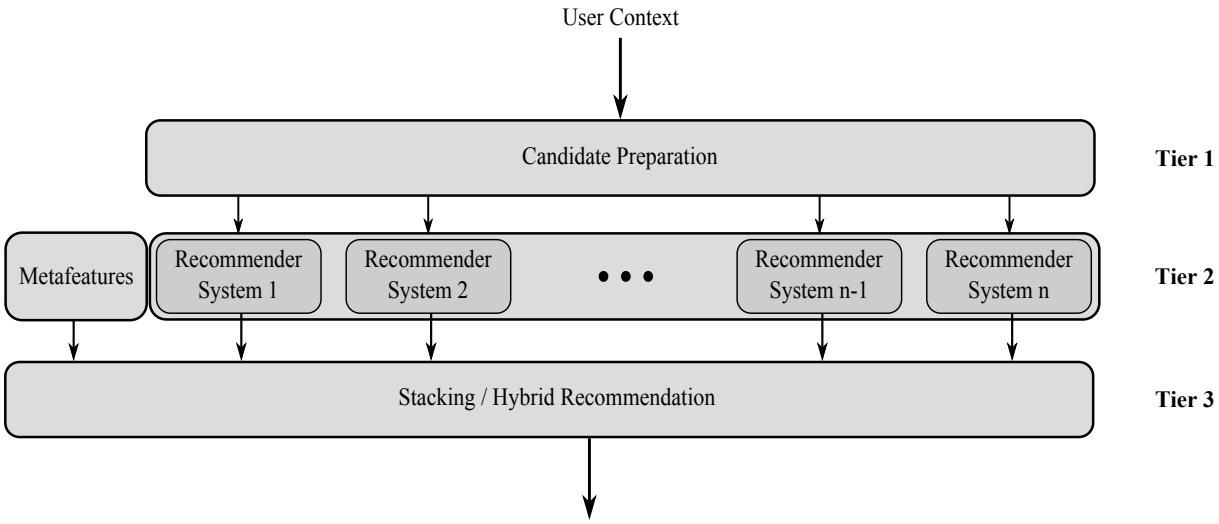

Fig. 1. 3-Tier-Architecture of the WEITBLICK recommendation engine

filter settings are removed from the candidate list as well. Other possibilities to constrict the candidate list include extending the time filter according to spare time from a user calendar with appointments or using information about disablities to remove services not feasible with the users abilities. Furthermore items that are not feasible for other reasons are removed from the candidate list as well. For instance public authorities have a certain area of responsibility, some delivery services only operate within a given radius etc.

4.2. Single Recommender Systems

After selecting candidate items that fit to the short term interest of the user, these candidates have to be rated according to the knowledge about long term preferences of the user. Therefore, the second recommendation engine tier consists of several different recommender systems. These systems estimate all for theirselves the usefulness of all the candidates from tier 1 for the current user. As most basic recommender system algorithms represent a certain assumption of user behaviour, it is advisable to select a wide range of recommender systems in this tier. Within the WEITBLICK recommender system, where geospatial relations are identified as especially important, several different approaches to incorporate geographical informations can be integrated here as well. We propose to use at least one implementation of each of the following groups:

- *Collaborative Recommender System:* Based on the assumption "users who liked similar items in the past will like similar items in the future," similarities between user ratings for items are used for prediction of unknown ratings. Methods to incorporate geospatial relations between user and items into collaborative recommender systems are introduced in [4] and [5].
- *Content-Based Recommender System:* Profiles, that represent features of items a user likes, can be utilized to predict whether new items will be liked by the user or not. For such approaches, no information about other users, but additional information about the content of recommender items is needed. This information is often provided by analyzing textual descriptions of recommender items with information retrieval approaches like TFIDF measures [6]. But also geographic features, like accessibility or connection to public transport can be usefull.
- *Demographic Recommender System:* While collaborative recommender systems calculate similarity of users solely on the basis of the ratings of items, demographic recommender systems use additional data about the user to classify them according to their demographic background. Besides "real" demographic features as age, gender, profession, etc., information about personal interests and state of health can also provide usefull knowledge to classify users and user preferences. Data from a survey of the targeted user group of WEITBLICK as described in [7] has successfully been used to train such a demographic recommender system [8].
- *Location-Based Recommender System:* As previously noted, all groups mentioned above might also use geospatial information to increase recommendation accuracy. But it is also possible to generate recommendations exclusively from location based information. Simple implementations of this concept will just rank items based on distance. Furthermore user choice models like the one proposed by Fotheringham in [9] consider more complex spatial relations.

4.3. Stacking

In the third and last tier, the results from the single recommender systems in the second tier are combined to a final, single recommendation result. Bao et al. [10] showed that the stacking method known from other machine learning applications can be applied to recommender systems as well. Stacking or Stacked Generalization is a method to combine the results of several machine learning algorithms. The results of the different algorithms are used as inputs for another machine learning algorithm, furthermore additionally information from simple metrics about the data quality are also used as input. Such approaches can yield better learning results than the single algorithms by theirselves.

Bao et al. proposed metrics like the number of items the current user rated, the number of users that rated the current item, the number of users that rated the same items as the current user etc. as metrics for stacking recommender systems. When geospatial information are used in the single recommender systems, additional metrics like the number of users living within a radius of 1, 2, 5, ... km, the number of items the user rated within a radius of 1, 2, 5, ... km around the current item etc. can provide further useful information for the stacking process.

According to the classification of Burke [11] this approach of stacking recommender systems can be classified as a weighted hybridization of recommender systems.

5. FUTURE WORK

In the development of the WEITBLICK recommender engine, several recommending approaches have already been implemented and evaluated, either with synthetic data [4, 5] or data from a survey of potential users of the system [8]. Further work has to be done in evaluating the proposed system in more realistic settings with potential users. Also additional recommender system approaches should be evaluated regarding their potential benefit for the WEITBLICK system. The evaluation of the abovementioned recommender systems followed the work of Herlocker et al. [12] and further evaluation works will also be oriented on this guidelines.

In the work of Bao et al. [10], linear regression, model trees, and bagged model trees are used as meta-learning algorithms for stacking the results from the single recommer systems. Here further experiments can be conducted to test the abilities of other algorithms. For instance the $\mathrm{EG}^{\pm}$-algorithm of Kivinen and Warmuth [13] might be promissing when incorporating lots of single recommenders with different recommending qualities, as it is robust to noisy inputs. The algorithm is related to the gradient descent algorithm and has been used successfully in [8] for a demographic recommender system.

A crucial point for the successful operation of recommender systems is the presentation of the results to the user. Furthermore giving feedback about the items in the form of ratings is necessary for obtaining good recommender results but should not be a burden for the user. For these reasons, the user interface of the WEITBLICK system has to be designed carefully and evaluated in close co-operation with the potential user group.

6. CONCLUSION

In this paper, the concept of personalized information brokering for the WEITBLICK system is introduced. The architecture consists of three tiers, one for prefiltering and candidate preparation, one for rating these candidates according to different recommender system approaches and a third tier to combine these ratings with the help of additional meta-features.

By using such an approach it is possible to combine knowledge which influences the long-term as well as the short-term decision and choice behaviour of the user. Furthermore different approaches, of which each depicts just a single or a few aspects of decision behaviour can be joined in one system.

As the system is easily expandable, it offers room for further research and therefore improvement of the recommendation results.

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8. REFERENCES

[1] Sibylle Meyer and Heidrun Mollenkopf, Eds., *AAL in der alternden Gesellschaft – Anforderungen, Akzeptanz und Perspektiven – Analyse und Planungshilfen*, VDE Verlag GmbH, Berlin, Offenbach, 2010.

[2] Carsten Stiller, Fred Roß, Christoph Ament, Karsten Renhak, Jochen Seitz, Eckhardt Schön, Hans-Peter Schade, Holger Hildebrandt, and Mark Oswald, "WEITBLICK – Infrastruktur

für eine bedarfsgerechte Dienstleistungsvermittlung," in *2. Deutscher AAL-Kongress 2009*, Jan. 2009, 5 pages.

[3] Gediminas Adomavicius and Alexander Tuzhilin, "Toward the Next Generation of Recommender Systems: A Survey of the State-of-the-Art and Possible Extensions," *IEEE Transactions on Knowledge and Data Engineering*, vol. 17, no. 6, pp. 734–749, June 2005.

[4] Carsten Stiller, Fred Roß, and Christoph Ament, "Towards Spatial Awareness in Recommender Systems," in *Proceedings of the 4th International Conference for Internet Technology and Secured Transactions – ICITST'09*, Nov. 2009, 5 pages.

[5] Carsten Stiller, Fred Roß, and Christoph Ament, "Ramp-Up-Effects in Spatial Aware Recommender Systems," in *Proceedings of the 4th International Conference on Ubiquitous Information Technologies and Applications – ICUT'09*, Dec. 2009, pp. 171–175.

[6] Gerard Salton, *Automatic text processing: the transformation, analysis, and retrieval of information by computer*, Addison-Wesley, 1989.

[7] Stefan Lutherdt, Carsten Stiller, Katrin Lienert, Sabine Spittel, Fred Roß, Christoph Ament, and Hartmuth Witte, "Design of an assistance system for elderly based on analyses of needs and acceptance," *LNCS: Universal Access in Human-Computer Interaction. Proc. of the 5th Int. Conference UAHCI 2009*, pp. 96–105, July 2009.

[8] Carsten Stiller, Fred Roß, and Christoph Ament, "Demographic Recommendations for WEITBLICK, an Assistance System for Elderly," *10th International Symposium on Communications and Information Technologies – ISCIT 2010*, Oct. 2010, accepted.

[9] A. Stewart Fotheringham, "Consumer Store Choice and Choice Set Definition," *Marketing Science*, vol. 7, no. 3, pp. 299–310, 1988.

[10] Xinlong Bao, Lawrence Bergmann, and Rich Thompson, "Stacking Recommendation Engines with Additional Meta-Features," in *Proceedings of the third ACM conference on Recommender Systems*, 2009, pp. 109–116.

[11] Robin Burke, "Hybrid Recommender Systems: Survey and Experiments," *User Modeling and User-Adapted Interaction*, vol. 12, pp. 331–370, 2002.

[12] Jonathan L. Herlocker, Joseph A. Konstan, Loren G. Terveen, and John T. Riedl, "Evaluating Collaborative Filtering Recommender Systems," *ACM Transactions on Information Systems*, vol. 22, no. 1, pp. 5–53, Jan. 2004.

[13] Jyrki Kivinen and Manfred K. Warmuth, "Exponentiated Gradient versus Gradient Descent for Linear Predictors," *Information and Computation*, vol. 132, pp. 1–63, 1997.