Smart Media Services through TV Sets for Elderly and Dependent Persons

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Abstract. This paper deals with providing adapted media content and services for elderly and dependent persons living alone. In our approach, providing solutions and technologies for elderly requires to consider the simplification of architectures and the acceptance of the user. We propose to provide content and services using familiar TV sets and to consider medical advices and recommendations in using media and TV programs. As the user control is a key criterion in adopting context-aware systems, we consider the user actions and preferences. The proposed media selection scheme considers the evolution of the user preferences based on the recent user behavior patterns.

Keywords: Healthcare, TV program recommendation, recommendation systems, user behavior, pervasive computing, home automation, smart home.

1 Introduction

Smart homes represent an application of pervasive environments that involves the integration of different services by using a common communication system. Smart home technology promises tremendous benefits for an elderly and dependent persons living alone. The environment provides user context-aware services like comfort, healthcare, safety and energy conservation. Many smart home projects and architectures have been conducted over the last decades [1]. However, proposed systems are always faced to the problem of their adoption and real use by the general public. For elderly, this situation is explained by the system complexity and the acceptance of new technologies. For example, DLNA digital home systems [2] are already integrated in about 74 % of existing home consumer electronics but with only 6 % of real users [3]. This fact is due mainly to the complexity of the technology and the lack of intelligent services/components that help users to find content, configure and connect their terminals.

Robles and Kim [4] concluded in their review that a main challenge of installing a smart home system is balancing the complexity of the system against its usability. Based on the work of [5], half of all computer-based information systems related to health care fail due to user resistance and staff interference. The main reason is that users were asked to significantly alter traditional workflow patterns to accommodate the system, rather than the system accommodating the users. According to a study done

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within 300 people of 65-85 years old [6], elderly are constantly faced to the ever-evolving technology and need appropriate support in order to satisfactorily meet with the difficulties of everyday living. The study shows that elderly are able to handle the TV sets (99.4%) while only 67.7% of them are able to use a simple wireless phone. Old people are using television more than other media and devices for many reasons. Mainly, because of the easy combined availability of verbal and visual information and sometimes to replaces lost social contacts, maintain a sense of participation in society and combat feelings of loneliness. Decreases in the ability to read and lower attendance at religious services and organizations both lead to increased TV viewing [7].

Providing smart media services through TV sets allow elderly and disabled to have personalized content adapted to their needs without leaving their homes and without complex home architectures. Furthermore, enabling smart services using familiar TV sets simplifies the use of advanced technologies and makes their integration in home easily accepted by elderly. The trends in smart homes research indicate an increasing popularity of using middleware. The use of middleware is efficient to integrate heterogeneous multivendor devices that coexist in the same system [1].

UNIVERSALLY [8], [9] is a middleware based architecture that provides media services in digital homes. The goal of UNIVERSALLY is to simplify and optimize digital home architectures and make their use intuitive. The system used an optimized way to deliver media services for heterogeneous renderers connected through different access technologies [8], [9]. In this work, we extend UNIVERSALLY in order to offer personalized media content and smart services though TV sets. Provided content are dynamically selected from TV programs and other media items (stored in the proposed system or coming from the Internet). Provided services depend on the elderly situation and could be notifications to take medicine or to go to sleep, incoming calls from family or assistance organisms, etc.

The new system components are designed to be easily used in both advanced digital homes (e.g. a DLNA compatible home [2]) and in simple homes where a simple TV set is used by the elderly. The idea behind the use of TV sets is to take advantage of the observed increased TV viewing by elderly living alone to personalize the watched media content. This automatic personalization, called also *media selection*, is made according to the elderly situation, preferences over the time, needs of contact and assistance. Moreover, at any moment, the user has the choice to control or change automatic selected media content and services. This aspect aims to further facilitate the user adoption of the system as it was pointed in many previous works regarding the satisfaction of the user in using context-aware applications [10].

Our cost-effective approach tuned towards preferences and needs of the users and the use of the familiar TV set (already existed in the elderly home) would accelerate the rapid adoption of the system and increases the acceptance of advanced technologies and services by elderly. The reminder of this paper is organized as follows. Principles of the context aware media selection are presented in Section 2. In Section 3, our proposed media selection scheme is discussed. The system rules required in providing our smart services are described in Section 4. Rules concern the system behavior in handling events and the user actions. The system implementation and experimentations are presented in Section 5. Conclusions are given in Section 6.

2 Context-Aware Media Selection

In order to provide smart services through the elderly TV set, the system must be able, at any moment, to display the most appropriate media content or service. This is the primary scope of the *context-aware media selection* problem. For TV programs, previous works have addressed the problem in the form of TV recommendation techniques. These techniques aim to avoid the blindly zapping of channels and help users to find their favorite TV programs. In [11], a recommendation system is presented for Web-TV content based of the user preferences and users rating. Recommendation techniques can be classified mainly into two common categories: *Content-based* recommendations and *Collaborative filtering* recommendation [12], [13]. In the first category, the similarities between the watched content and new content are considered. The second category is based on the content recommendations of other TV viewers having similar preferences as the user. Collaborative rating and filtering are not considered in our work because we believe that rating the viewed content does not simplify the system for the elderly. Our objective is to leave the elderly using the TV set as usual with its own remote controller.

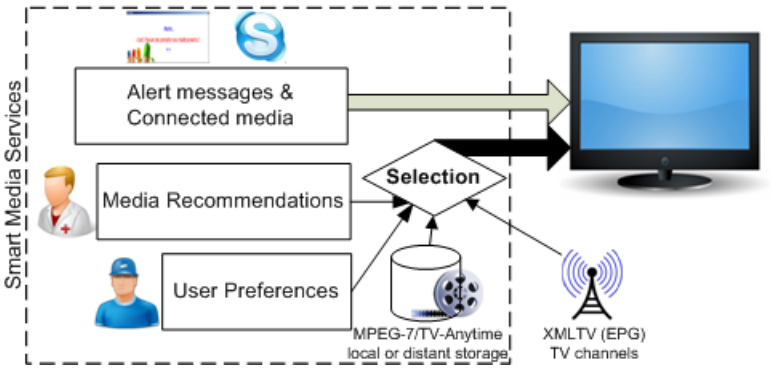

Fig. 1. Media selection based on the *Media Recommendations*, *User Preferences* and the description of TV channel content and available external media

Bearing in mind that the focus is on comfort and healthcare for elderly and dependent persons, our model considers the following aspects (Fig. 1):

- ***Media Recommendations*** for the user considered as elderly or a dependent person. These recommendations are intended to be advised by the referring doctor, a caregiver or a healthcare assistant that follows the elderly. For example, these recommendations aim to find what external media[1] content is considered adapted to the user situation (age, health situation and culture). In other words, what content can be better for the user than any arbitrary TV channel content. Moreover, media

[1] We define an external media as a media content (video or audio) that does not come from a current TV channel but from a local or distant storage used by our system.

recommendations include the maximal recommended time to spend in watching TV, times to take medicine for the elderly and recommended time to sleep.

- ***User preferences***. The content the user likes to watch as expressed by him. The content can come from a TV channel or an external media. The user preferences are expressed once. However, our system may change the preferences over the time according to the user behavior.
- ***Alert messages***. Alert content for health and safety such as the notification when it is time to take medicine.
- ***Connected media***. The received calls from family, friends or assistance organisms.

Table 1. An example of a *Media Recommendations* profile

Media Recommendations	
Content Category	**Percentage per Week**
Relaxation Atmosphere: Laid back (Calm, relaxed, easy-going)	50%
Daily news, regular program carrying breaking and current news stories	20%
Leisure/Hobby/Lifestyle, Personal/Lifestyle/Family, Fitness/Keep-fit and House Keeping	15%
Humanities, Culture/Tradition/Anthropology/Ethnic studies	10%
Sports, Winter sports, Ice-skating	5%
Other Variables	**Value(s)**
Maximal Recommended TV Time per Day	5h per day
Medicines Times	10:00 AM, 04:00 PM
Level of Hearing	medium
Time to Sleep	10:00PM

Table 2. An example of a *User Preferences* profile (a French viewer)

User Preferences	
Content Category	**Percentage per Week**
Similar structure as the Media Recommendations profile but with the user favorite categories	
Favorite presenters/actors	**Value(s)**
Presenter/actor	Louis de Funès
Presenter/actor	Tex
Other Variables	**Value(s)**
Preferred Sport	Ice-skating
Preferred General Channel	M6
Preferred News Channel	iTélé
Preferred programs	**Value(s)**
Title / Channel	Les feux de l'amour / TF1
Title / Channel	Un dinner presque parfait / M6
Title / Channel	Les Z'amours / France 2

Recommendations and user preferences are stored in the form of two separate profiles that include the needs and preferences regarding the content. In Tables 1 and 2, we give an overview extracted from a *Media Recommendations* and *User Preferences* profile. Recommendations and preferences profiles are stored in RDF [16]; the media content categorization uses the schema defined in the ETSI TV-Anytime specification (version 1.7.1) [14]. Media content analysis is done on the metadata provided by the used media formats MPEG-7 and TV-Anytime. The content analysis of TV channels is applied on an XMLTV format [17] based on EPG data received using a TV card.

3 Media Selection Scheme

As shown in Fig. 1, we consider alert messages and connected media a priority. This means that when it is time to display an alert message or when a call is received, it will be displayed on the TV set. Hence, the media selection problem will be limited to the media recommendations, the user preferences and the available media items (external media and current TV channel content). The media diversity of the selected content is also considered to avoid boring the TV viewer with the same category of content.

3.1 Proposed Scheme

The media selection is applied on available media sources: external media items and current TV channel programs. The result of the media selection is the decision to either play an external media item or select a TV channel program. The selection is based on the metadata of the content: MPEG-7 or TV-Anytime for external items and XMLTV for TV channel content. Each media item viewed by the elderly is logged. A log entry includes mainly the fields represented in Table 3.

Table 3. A log entry of the elderly TV viewing activities

Title	*Category*	*SubCategory1*	*SubCategory2*	*Metadata*	…
…	*PassingTime*	*WatchingTime*	*MediaDuration*	*Source*	

The media selection scheme performs the following phases:

- **Phase 1:** Based on the user behavior patterns in the seven last days, find the set of media items S_1 that fulfills the requirements of the *Media Recommendation* profile. This means to do the best effort to reach the given percentage per category and to keep the given proportion between the different percentages.
- **Phase 2:** Order the S_1 set according the score function *MediaScore* that takes into account the recent behavior patterns of the user. The *MediaScore* function will be discussed later. We denote S_2 the set returned at the end of this phase.
- **Phase 3:** Order the S_2 set according to the current *User Preferences* profile. Items of S_2 are evaluated according to the user preferences dimensions in the following order: does the item belong to the preferred programs list? Is there any favorite presenter/actor in the media item? Does the item fulfill the preferred

content categories percentage and proportions between percentages? Finally, evaluate the item according to the other variables of the *User Preferences* profile. We denote S_3 the set returned at the end of this phase.

- **Phase 4:** Select the top media item of S_3.
- **Phase 5:** Update the log of the user behavior patterns with the selected item in Phase 4.

If the user performs a selection action (example turning off the TV set or zapping a selected program), the system will apply the ***UpdateUponAction*** procedure as follows:

- Updates the log of the user behavior patterns,
- Updates the current preferences according to the passing time, watching duration and media duration of the last viewed item using the *MediaScore* function.
- Updates the current elderly status regarding to the requirements of the Media Recommendations profile. This means to update the different percentages of viewed content categories and subcategories, the daily time spent in watching TV and initializing the energy saving timer (if the TV set still on). The energy saving timer serves to turn off the TV set if no action from the user is captured within a fixed time value (*EnerySavingValue* constant). The default value of *EnerySavingValue* in our system is four hours.

At a given moment, the number of available TV programs and external media items is important. Performing the previous phases requires a non-negligible computing time that can affect negatively the elderly experience. Indeed, the computing time required for the media selection implies that the elderly will have no displayed content before the result of the selection. Our approach is to perform the different phases of the media selection scheme offline, i.e. when the TV set is off or when the user is already watching a media item. The result of the selection is stored temporarily. When the user performs a new action, the temporarily result is updated in order take into account only the time spent to watch the last item (*WatchingTime* value). If the user zaps quickly a media item, updating the temporarily result of the media selection will be fast because the last zapped item will not affect significantly neither the media selection result nor the user behavior patterns. Indeed, as we will see later, if the user spent a short time to watch a media item, this implies that the score of this item will not be significant. This is due to the recent passing time of the media item and its short watching time value.

3.2 Evaluating the Media Score

Our scheme aims to further facilitate the elderly adoption of the system. As stated earlier, previous works have pointed the user's need of control in order to satisfy him in using context-aware applications [10]. Our system gives the user the choice to control and change selected media content at any moment. Our scheme includes this

user control patterns to adjust the user preferences and so the scores associated to media content items. If the user selects and spends more time on watching a given media item, the item's score will be increased. If the user spends less time or simply ignores an automatic selected item, the item's score will be decreased. The tacit assumption is that the elderly selection of media is a reflection of his preferences that can be learned. However, as the elderly preferences may change over time, we focus on the recent behavior patterns of the user.

The following equations are used to evaluate the score of a media item *I* according to the viewing patterns of the user (using logs). We consider the watching time and the passing time of similar media items *j*. *WatchingTime* (*j*) returns the time that user spent to watch the item *j* divided by the total duration of *j*. In (1), we consider that an item *I* will have a better score if the viewer found an interest to stay for a long time watching similar content. Content similarities consider the same category and subcategories with similar metadata. However, in order to avoid boring the user with repeated selections of the same content and the same categories, we will consider the passing time importance factor δ. $PassingTime_j$ returns the most recent week in which the item *j* was watched. In order to avoid repeated selections that return the same result, the δ factor will be positive if the item was watched recently but at least one week ago. As the elderly preferences may change over time, items watched before the last four weeks will have a negative importance factor (Equation 2). In (2), α is a constant that adjusts the importance factor δ to be in the range of 0 to 100 (for a passing time from one to four weeks). The value of α is 44,44.

$$MediaScor(\mathrm{I}) = \sum_{\mathrm{j}} \delta_j \cdot WatchingTime(j) \tag{1}$$

$$\delta_{\mathrm{j}} = -\alpha \cdot \left(Pas\sin gTime_j - 1\right) \cdot \left(Pas\sin gTime_j - 4\right) \tag{2}$$

4 Rules Implementation

In this section, we present the different rules required to implement smart media services through the TV set of the user. The system takes into account the *Media Recommendations* and the *User Preferences* profile discussed previously. Services include displaying available TV programs, external media items, incoming calls and different alerts. The implementation of incoming calls detection and termination is done based on the network capture of the traffic. The user actions are capture using an infrared sensor (see Section 5). Rules implementation follows the condition/action model i.e. when a given condition is satisfied the smart system performs a given action. In our system, conditions are related to the user control or particular events.

User control **(rules: R1, R2, R3)**
R1 (condition): *the user turns on the TV Set*
R1 (actions):

- Apply the Media Selection Scheme;
- Display the selected Item on the TV Set;
- Initialize the energy saving timer;
- **If** (*time to sleep* OR *the maximal recommended TV time per day* is exceeded) **Then** Display an alert message every thirty minutes;

R2 (condition): *the user turns off the TV Set*
R2 (actions):

- Apply the *UpdateUponAction* procedure (Section 3.1); (except the initialization of the energy saving timer)
- Stop playing any external media if it was displayed on the TV set;

R3 (condition): *the user zaps the current media item*
R3 (actions):

- Perform the user's action; (this means that the system will accept the user control. The media selection process will not be called. The system lets the TV set displays the desired TV channel)
- Apply the *UpdateUponAction* procedure (Section 3.1)

Events **(rules: R4, R5, R6, R7, R8)**
R4 (condition): *a media item is completely watched*
R4 (actions):

- Updates the *WatchingTime* value of the last watched item; (this field is updated in the user's log with the value of: current time minus the *PassingTime* value)
- Apply the Media Selection Scheme;
- Display the selected Item on the TV Set;

R5 (condition): *it is time to sleep* OR *the maximal recommended TV time is exceeded*
R5 (actions): Display an alert message every thirty minutes;
R6 (condition): *it is time to take medicine*
R6 (actions):

- Display an alert message;
- Perform a pause on the current media item if it is an external media;

R7 (condition): *no user action is received within the value of EnerySavingValue*
R7 (actions):

- Turn off the TV set;
- Apply the *UpdateUponAction* procedure (Section 3.1); (except the initialization of the energy saving timer)

R8 (condition): *a call is received*
R8 (actions):

- Display the call on the TV set;
- Perform a pause on the current media item if it is an external media;
- Exclude the call interruption in the *WatchingTime* value calculation;

In addition to the previous rules, the system performs a volume adjustment each time the TV set is turned on or when an external media item or a new TV program is displayed. Volume adjustment is based on the *Level of Hearing* value (*normal*,

medium, *hard*, *very hard*) expressed in the *Media Recommendations* profile. Volume adjustment is based on the real volume as sensed by the system using an embedded microphone (Section 5). This choice is due to the difference of the real output TV volume between: a TV channel and another one; a TV program and an external media; different models of TV sets and finally between the volume of a TV program and its included commercial advertisements.

5 System Implementation and Experimentation

In order to validate our approach, we have enriched the UNIVERSALLY system [8], [9] by the implementation of the context-aware media selection scheme, the user control management and rules of the user control and events (Fig. 2).

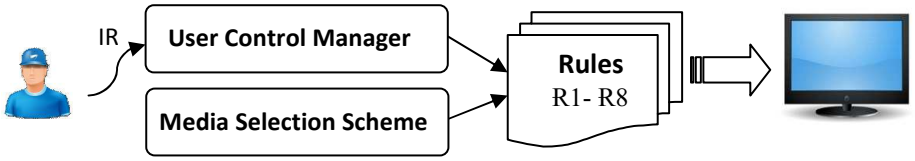

Fig. 2. The system components

In order to implement the *User Control Manager*, we use a USB infrared receiver and transmitter (*USB-UIRT* [15]). The device allows learning and receiving the infrared signals that the user transmits using his remotes. The device allows performing different actions on the TV set according to the specified rules. The implemented basic actions are: turning on/off the TV set, adjusting the volume, selecting the TV video/audio source (channels or PC) and the selection of TV channels. Actions are implemented using the *USB-UIRT trydrv* and *uutx* commands [15]. The infrared receiver/transmitter is connected to a personal computer (*DELL Precision M6300*) where the system components are implemented. The TV set (*Sony KDL-46Z5500*) is connected to the PC through a scart and audio cables. For incoming calls, we use a web camera (*Logitech HD Webcam C310*) with a built-in microphone used also in volume sensing and adjustment discussed in section 4. Figure 3 shows three tested scenarios in the house of *Marie* a 60 years old elderly person. In (A), the system selected automatically a preferred program ("*almost perfect dinner*", in French "*un dinner presque parfait*", from the French *M6* channel). In (B), *Marie* received a skype call from her daughter *Lydie*. The system switches automatically the TV set to the computer call. *Marie* was able to perform the call using the camera with built-in microphone used by the platform. In (C), *Marie* was watching a selected media item; the system notifies her to take her medicine.

6 Conclusion

In this paper we have described how smart media services can be provided to elderly and dependent persons using their TV sets. We have proposed a media selection scheme

base on the *Media Recommendations* and *User preferences* profile. The system considers the media recommendations to provide content and services adapted to the user situation and health. Selected media are closer to the user needs and preferences than any arbitrary TV content obtained after a blindly zapping. Our proposed scheme considers the change and evolution over time of the user preferences and makes selected media items dynamically adapted to current preferences. The proposed approach made the system tuned towards preferences and needs of the elderly. The use of TV sets increases the acceptance of advanced technologies and services by elderly. The user's acceptance of the proposed system was a key criterion in our approach. Unfortunately this aspect is generally ignored in previous context aware approaches. The next step of our work will concern the evaluation of the user acceptance and quality of experience in using our system. Concretely, one of the identified metric is to measure, over time, the number of media items returned as a result of our selection scheme and zapped by the user. This number should decrease if the user is satisfied. Also, we will consider the time spent to watch selected items and enabling the dynamic change of the proposed *Media Recommendations* profile.

(A) (B)

(C)

Fig. 3. Three tested scenarios: preferred program (A), incoming call (B) and medicine notification (C)

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