An Ontology Based Adaptation of User Interface for People with Special Needs

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***Abstract*—This paper presents a two-phase method of user interface adaptation for people with special needs based on ontological user model, rule-based reasoning over ontology and interface design patterns. The method implementation is introduced by an example of user interface adaptation for people after ischemic stroke.**

I. Introduction

A problem of disabled people socialization becomes more important from year to year. According to recent researches [1] over a billion people have some form of disability, this number is equal to 15% of the world's population. Moreover, the report brought the facts that amount of disabled people will be raising due to chronic health conditions increasing and population ageing.

Despite the fact that there is a large number of social adaptation programs, disabled people still experience a lot of difficulties in everyday life because of social barriers.[2]Besides a political and economical barriers, shortage of social services this group of people experiences lack of communication, what makes social barrier around them.

Wide spread of mobile technologies can provide numerous services for solving a great part of the everyday life problems for disabled people. The main negative aspect of these services is their low usability for people with disabilities. Most applications can not be useful for people with health problems because of disease's peculiarities in physical, emotional and cognitive aspects. A person with certain disease can face several difficulties in interaction with graphical interface of mobile applications.

The usability problem appears when developers and interface designers do not consider the requirements to interfaces for disabled people. Firstly, it takes a lot of resources to create an interface, which would satisfy the most of common requirements for a wide set of diseases of different nature. Secondly, the developers do not exactly know all requirements to graphical interfaces for people with special needs. Finally, the developers often can not meet fully the individual requirements of all application users.

As a result the people with disabilities have limited access to the useful mobile applications, which can reduce the impact of communication and information barriers on their life. Our research is focused on the problem of interface adaptation and development of the personalized adaptive user interface for people with disabilities. This paper describes a two-phase method of the interface adaptation on the basis of ontological user model, rule-based reasoning over ontology and interface design patterns.

II. The state of the art

A lot of new approaches are recently appeared to improve the life of people with disabilities in sphere of computer technologies. Numerous researches are devoted to the development of user models including ontological user model to provide the adaptivity and personalisation of user interface.

An ontology as a user model is used in EGOKI Adaptive System [6]. This application allows to create the adaptive user interface in xml format. Ontology model also contains some extra information about the software and hardware components of user's device, localization and personal preferences in interface usage such as preferred color, font, etc.

One more ontology-based approach to development of adaptive user interface is described in [5]. This research is directed to the personalization of context-aware applications within mobile. Ontological user model contains the important information for context such as user activities and capabilities, area of interests and preferences, health conditions, user location, etc.

Other view on the graphical interface adaptation is presented in MyUI Adaptation Framework [4]. This framework creates adaptive graphical interfaces for interactive TV set. The main idea of the approach is to use the best practice patterns in adaptation process. All patterns are divided into four groups: generic patterns for defining the global settings of TV interface such as font size or color; interaction patterns for providing the suitable interactive elements for each person; common patterns for defining the stable features as screen orientation or basic layout; and transition patterns for defining the mechanism of switching between common or interaction patterns. During the process of user interaction with TV the framework collects information about user, when the conditions of certain pattern become true the pattern is applied to interface. It continues until user turns off the TV.

We have considered some more approaches to interface adaptation [3],[7],[10] and concluded that ontology-based approach is not usable for real-time adaptation whereas interface design patterns approach seems to be good solution to implement this process. Ontology-based approach can be extended with interface patterns for the purpose of support of real-time

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interface adaptation. In this paper we propose a two-phase method of interface adaptation which uses both the ontological user model and the interface patterns.

III. Two-phase method of user interface adaptation

The proposed approach to user interface adaptation combines both the use of ontology as a user model and interface design patterns. The ontological user model is described in [11] and is used for representing knowledge about the user's diseases, the problems, which are occurred during the process of user interaction with the interface, and the possible interface solutions. The inference over ontology on the base of semantic rules allow to obtain the appropriate interface profile for the user with special needs.

Design patterns contain the best practices of interface constructions for people with special needs, most of them are described in [8]. We developed a set of the patterns which are represented by the following way [4]: each pattern has the name, trigger condition and list of the components that must be applied to the interface when the trigger condition of pattern becomes true. The proposed adaptation method consists of two phases: phase 1 - initial adaptation based on the ontological user model; phase 2 - real-time adaptation based on the analysis of data about user behaviour and applying the appropriate patterns.

The first phase of method begins when a coach defines the user profile of the disabled person. The reasoning mechanism allows to obtain the interface solutions for current user in accordance with his pecularities and parameters of his mobile device. At that the conflicting situations are taken into account, when the user has multiple diseases which require to apply the mutually exclusive interface solutions. Pseudocode of the phase 1 is presented in Algorithm 1. As a result of phase 1 execution the common interface is generated, which is suitable to the user disease or set of diseases.

Phase 2 of algorithm runs during the whole process of interaction between user and application. Some parameters, like number of clicking on object or region near this object, time between clicking on two buttons, time of text input, etc are caught by the system. After that the event is analysed and some valuable parameters are saved into the event database. Also we need to check if current event changes the pattern condition. If it happened, the pattern must be applied to the user interface, else the process of collecting and analyzing the user behaviour will continue. Pseudocode of the phase 2 is presented in Algorithm 2. As a result of phase 2 the personal adaptive interface is generated, which considers user peculiarities.

Algorithm 1 Phase 1 - Initial graphical interface adaptation

```
for all disease ∈ User'sDiseases do
  Get all physical Problems of disease.
  for all problem ∈ Problems do
    Check problem on compatibility with current graphical interface.
    if problem appears during interface interaction then
      Add problem to Interface Problems
    end if
  end for
end for
for all interfaceproblem ∈ InterfaceProblems do
  Get Interface Solutions for problem.
  for all solution ∈Interface Solutions do
    Check solution on consistency with other solutions.
    if solution is not contrary to other solutions then
      Add solution to Current Interface Solutions.
    else
      Resolve conflict situation according to resolving rules.
    end if
  end for
end for
for all solution ∈Current Interface Solutions do
  Apply solution to current graphical interface.
end for
```

Algorithm 2 Phase 2 - Real-time graphical interface adaptation

```
while Application is running do
  Catch event of user's interaction.
  Save event information to Event Database.
  if event information triggered pattern in Pattern Database then
    Apply pattern to current graphical interface.
  end if
end while
```

IV. An example of user interface adaptation

Procedure of interface adaptation can be introduced by the following example. People after ischemic stroke have some physical problems and can not serve themselves in everyday life. For example user with lacunar syndrome subcortial stroke (LACS) has several post-effects such as pure sensory stroke, ataxic hemiparesis and unilateral weakness of face and arm. In addition to this the user has middle vision impairment.

Suppose that user with these post-effects needs to perform the following interface task - to enter his name and press accept button. The inference over the developed ontology [11] shows that user with LACS disease can not easily perceive visual information and work with touch screen to input text or push the buttons. Therefore the interface developers should design the interface using audio as a way for data output to avoid the use of visual data and should use audio or some special devices (for example trackballs) for data input to avoid the use of touch screen as a way of data input. Design patterns for building this interface are shown below in Tables I, II, III.

At the first phase of adaptation method the suitable patterns according to the user's disabilities should be retrieved. Current user has problems in perception of visual information, so he

TABLE I. EXAMPLE OF A DESIGN PATTERN: "INTERFACE ELEMENT AUDIO OUTPUT"

Pattern name	Interface Element Audio Output
User's problem	User can't recognize *Interface Element* to read text on it
Condition of applying	*Vision Impairment Range* >Medium **and** *User's Device* has dynamics
Solution	Replace *Interface Element* with *Audio Output Interface Element*

TABLE II. EXAMPLE OF A DESIGN PATTERN: "INTERFACE ELEMENT AUDIO INPUT"

Pattern name	Interface Element Audio Input
User's problem	User can't use *Interface Element* to input data into it
Condition of applying	(*Vision Impairment Range* >Medium **or** *Motorics Impairment Range* >Low) **and** *User's Device* has microphone
Solution	Replace *Interface Element* with *Audio Input Interface Element*

can not read text on interface or input it in appropriate fields. Moreover, user has problems with motorics, so he can not click on buttons or choose interface elements for text input without problems.

Suppose that user's mobile device has microphone and audio dynamics. The conditions of two described patterns became true, that means that adapted interface should include audio input element and audio output element (Tables I, II).

At the second phase the interface which was generated at the first phase, should be improved to make it more personalized for current user. Suppose that the user did not heard audio output information. In that case if the application would not get any feedback from user during the next 30 seconds, then the condition of third pattern became true, and according to this pattern, the solution for this situation is to repeat the last audio information louder (Table III).

TABLE III. EXAMPLE OF AN IMPROVEMENT PATTERN: "REPEAT AUDIO OUTPUT COMMAND"

Pattern name	Audio Output Volume Increasing
User's problem	User can't hear *Feedback* from application
Condition of applying	*Time of Waiting* >30 seconds **and** *User's Device* has dynamics
Solution	Repeat *Last Command* with *Current Volume* + 20 percent

V. CONCLUSION AND FUTURE WORK

The two-phase method of user interface adaptation was developed, it includes the process of initial interface adaptation on the basis of ontological user model and reasoning over ontology, and interface adaptation in real-time using interface patterns.

This work is carried out in the framework of ongoing EU-project 'Community Service Engineering' which involves staff and students at Thomas More University, Geel, Belgium and Volgograd State Technical University, Russia. The main provisions of the proposed approach to interface adaptation are planed to be used for the development of software tool for designers and developers of mobile interfaces for people with special needs.

In the nearest future it is planned to apply the developed approach for adaptation of user interface of the mobile application for support of mobility and communication of people with intellectual and development disabilities 'Travel and Communication Assistant' [12].

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REFERENCES

[1] WHO official website, World Health Statistics 2015, Web: http://www.who.int/gho/publications/world_health_statistics/EN_WHS2015_Part1.pdf.

[2] WHO official website, World Disability Report 2011, Web: http://www.who.int/gho/disabilities/world_report/2011/.

[3] J. Abascal, A. Aizpurua, I. Cearreta, B. Gamecho, N. Garay, R. Minon, "A modular approach to user interface adaptation for people with disabilities in ubiquitous environments", *Internal Technical Report*, no. EHU-KAT-IK-01-11, Jan. 2011.

[4] M. Peissner, A. Shuller, D. Spath, "A Design Patterns Approach to Adaptive User Interfaces for Users with Special Needs", *in Proc HCII Conf.*, Jul. 2011, pp. 268-277.

[5] K.L. Skillen, L. Chen, C.D. Nugent, M.P. Donnelly, W. Burns, I. Solheim, "Ontological User Profile Modeling for Context-Aware Application Personalization", *Series: Lecture Notes in Computer Science. Springer*, Vol.7656, 2012, pp. 261-268.

[6] B. Gamecho, R. Minon, A. Aizpurua, I. Cearreta, M. Arrue, N. Garay-Vitoria, J. Abaskal, "Automatic Generation of Tailored Accessible User Interfaces for Ubiquitous Services", *IEEE Transactions on Human-Machine Systems*, Vol.45, No. 5, Oct. 2015, pp. 612-623.

[7] P. Llinas, G. Montoro, M. Garcia-Herranz, P. Haya, X. Alaman, "Adaptive Interfaces for People with Special Needs" *Series: Lecture Notes in Computer Science. Springer*, Vol.5518, 2009, pp. 772-779.

[8] *Office of the Government Chief Information Officer: Mobile Application Accessibility Handbook*. The Government of the Hong Kong Special Administrative Region, 2011.

[9] Disability: Definition, Types & Models, Web: http://www.disabled-world.com/disability/types/.

[10] E. Castillejo, A. Almeida, D. Lopez-de-Ipina, "Ontology-Based Model for Supporting Dynamic and Adaptive User Interfaces", *International Journal of Human-Computer Interaction*, No. 30, 2014, pp. 771-786.

[11] M. Kultsova, R. Romanenko, A. Anikin, A. Poceluico, "An ontology-based approach to automated generation of adaptive user interface based on user modeling", *in Proc. IISA2016 Conf.*, Jul. 2016.

[12] M. Kultsova, R. Romanenko, I. Zhukova, A. Usov, N. Penskoy, T. Potapova, "Assistive mobile application for support of mobility and communication of people with IDD", *in Proc. MobileHCI '16 Conf.*, Sep. 2016.