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Parameterized user modelling of people with disabilities and simulation of their behaviour in a virtual environment

Project Title: *Parameterized user modelling of people with disabilities and simulation of their behaviour in a virtual environment*

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Abstract:

The goal of the project is to develop mechanisms that will enable the parameterized user modelling of people with disabilities, the optimization of the virtual user models using feedback by real users and the simulation of the virtual user models in virtual environments. UsiXML language will be used for the definition of the virtual user models. A multisensorial platform will be used for the training of the parameterised user models based on real user measurements in real testing conditions. The platform will utilize interaction of real users in the virtual environments, in terms of their physical, cognitive and behavioural response, to tune the virtual models and provide sufficient feedback for the quantitative evaluation and verification of the user models. The multisensorial platform will support a multimodal interface enabling virtual testing in realistic scenarios that will offer the opportunity to tune and adapt these technologies to the specific application domains. Cross-modal transformation and temporary modality replacement techniques will be examined in order to achieve a better and more detailed definition of the user tasks. During the workshop the multisensorial platform will be used by a large number of subjects with different characteristics in order to achieve optimization of the virtual user models. Additionally, a simulation framework for the virtual user models will be developed including a parameterized avatar that will be able to interact in a virtual environment like a virtual user with disabilities and this will enable the accessibility assessment of the virtual environment for the specific user model.

Project objectives:

It is important to realise that people with disabilities are not just a tiny minority of the population of the European Union. The lowest estimate, based on the currently defined disablement categories, estimates their total number at around 74 Million persons. However, other estimates that take into account a) people with cognitive difficulties, and b) those people in the so-called hinterland between fully able bodied and the classically termed people with disabilities, should considerably raise those numbers, as highlighted below:

- In the EU 27 countries about 16% of the population are over 65, a number that is estimated to rise rapidly in the coming years[1].
- Up to 15% of the population across the European Union has a disability, such as a visual, hearing, speech, cognitive, or motor impairment[2].
- Around 20% of people over 50 experience severe physical disabilities
- Spending on pensions, heath and long–term care will rise sharply over the next 20 years

Despite the fact that people with disabilities are not just a tiny minority, in most cases the developers of ICT and non-ICT products and services toil to test and evolve their prototypes in terms of their functionality, without however being able to systematically test their developments in terms of their accessibility.

The main objective of the project is to introduce a new approach in user modelling of people with disabilities as well as new techniques in user models optimization and a simulation framework that will enable the simulation of the user models in virtual environments. The simulation framework will provide useful feedback concerning the accessibility evaluation of real environments for people with different types of disabilities by simulating the tasks of the virtual users in the equivalent virtual environments.

The specific goals of the project are:

1. To introduce new techniques for people with disabilities virtual user model generation based on UsiXML.
2. To introduce new techniques for optimization of the virtual user models based on real user measurements in real testing conditions.
3. To develop a framework for virtual user simulation and testing.
4. To make user modelling and simulation parameterized and automated.
5. To evaluate the accessibility of real environments for people with different types of disabilities by simulating the tasks of the virtual users in the equivalent virtual environments.

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[1] Eurostat yearbook 2008.

[2] Report of the Inclusive Communications (INCOM) subgroup of the Communications Committee (COCOM) COCOM04-08.

Background Information:

The concept of the user modelling has been previously employed in many research areas. The field of anthropometry, the study of human measurement, uses combinations of bodily lengths and perimeters to analyze body shape in a numerical way. The idea of using real-world data to model the variation of human shape has been applied to heads and faces several times. Complete human body models, apart from the physical characteristics, should describe the kinematic and kinetic properties of the body (the skeleton) as well. But even if the kinematic modeling of real humans aims to create corresponding virtual ones, almost all work done towards this direction until now does not take under consideration the special characteristics of older people and people with disabilities. Similarly, the research done so far in the field of cognitive as well as behavioural modelling, does not target people with special characteristics and/or disabilities. Concerning simulation modelling, even if there have been many efforts in the past, there are many compatibility problems between the simulation representation formats. Additionally, there is not any simulation platform with embedded accessibility evaluation and assessment of the design.

Detailed technical description:

A. Technical description

This project aims mainly to introduce new techniques for user modelling and virtual user models optimization and a framework that performs simulation of the virtual models in a virtual environment. The project is expected to contribute significantly in the following technical points:

WP1: Models library implementation and design of the architecture of the multisensorial and the simulation platform: A user model generator will be developed to enable the automatic extraction of the user models in UsiXML format. A library of user models describing users with various disabilities and/or special characteristics will be created using the user model generator. A library of simulation models (describing specific sequences of user tasks) will also be created using the IdealXML tool, which enables the extraction of a simulation model in UsiXML format.

The multisensorial platform has to be as extendable as possible including different sensors that will capture the several actions/reactions of the users to specific stimuli so as to provide quantitative measurements of their disabilities and fine tuning of the virtual user models. The simulation platform has to be as parameterized as possible while keeping various implementations aspects (graphics, interaction) generic enough in order to exploit the features of each virtual environment that has to be evaluated.

WP2: Optimization of the virtual user models using a multi-sensorial platform:

A multisensorial platform will be used for the training of the parameterised virtual user models based on real user measurements in real testing conditions. The platform will utilize interaction of real users in the virtual environments, in terms of their physical, cognitive and behavioural response, to tune the virtual models and provide sufficient feedback for the quantitative evaluation

and verification of the user models. The multisensorial platform will be fully parameterised and will be used to capture user feedback while executing a number of tasks that will be mapped in the user models. Special sensors will be used for data capturing including cameras for gait analysis in order to analyze user kinematic patterns while executing specific activities and tasks. Application-software based measurements will also be used. The multisensorial platform will support a multimodal interface enabling virtual testing in realistic scenarios that will offer the opportunity to tune and adapt these technologies to the specific application domains. In this respect, full advantage of the multimodal interface technologies is expected, fully exploiting the concepts of cross-modal transformation and temporary modality replacement. During the workshop the multisensorial platform will be used by a large number of subjects with different characteristics in order to achieve optimization of the user models.

WP3: Implementation of the simulation framework, including the parameterized avatar: The intended goal is the development of a functional simulation framework that will simulate the behavior of the virtual user models within a 3D virtual environment. First of all, a parameterized avatar that will be able to perform all the tasks described in a virtual user model will be developed. According to the disabilities described in the virtual user model, some tasks within the 3D virtual environment will be affected and these tasks may not be executed successfully by the avatar representing the specific user. Generally, the simulation framework will take as input a UsiXML file containing the description of the virtual user model as well as a UsiXML file containing the simulation model of a specific procedure (consisted of a set of tasks) and the parameterized avatar will then interact in the 3D virtual environment as a virtual user with disabilities trying to execute the tasks described in the simulation model.

WP4: Testing, validation, reports: Different techniques for validation and testing will be used to ensure the proper function of the multisensorial as well as the simulation platform. During the phase of validation and testing, reports will be produced describing in detail all the steps followed.

B. Resources needed

Facility:

- Room for 4-6 working participants.

Equipment:

- A personal computer will be needed for each participant.

Staff:

- Experienced researcher(s) in the area of virtual reality and/or virtual simulations.
- Experienced researcher(s) in the area of 3D modeling and 3D interfaces.
- Experienced researcher(s) in the area of accessibility of ICT and non-ICT products.
- Experienced researcher(s) in the area of user and task modeling.

C. Project management

The first task will be to split the participants in two groups:

1. Model optimization group
2. Simulation framework development group

During the workshop these groups will have close cooperation. At least two times per week meetings will be organized to discuss in detail the progress of the work and to plan the work of the following days, reorganizing the work schedule if necessary. Extra care will be taken in order to develop, in an initial step, a working framework based on the minimum of the desired goals and then build further on this by supporting more disabilities and tasks.

Workplan and implementation schedule:

Due to the restricted duration of the workshop, preliminary work, i.e. literature survey, team organization, etc., will be done before the starting date of the workshop. During the workshop and for each week the following schedule should be approximately followed.

1st Week:
The first week will be introductory for the participants. They will have to set up their computers according to the tasks they will have to follow during the workshop. The members of each group will discuss about their expertise and their contribution in the whole project. The major outcome of the first week will be a schedule with the tasks of each participant.

2nd Week:
During the second week each group will work on independent tasks. The tasks of each group during the 2nd week of the project are:

Group 1 (Model optimization group):

- Multisensorial platform setup
- Multisensorial feedback formal recording and analysis
- User models library update according to the feedback from the multisensorial platform

Group 2 (Simulation framework development group):

- Architecture design of the simulation framework
- Development of the parameterized avatar
- Development of the simulation framework

3rd Week:
During the third week each group will also work on independent tasks. The tasks of each group during the 3nd week of the project are:

Group 1 (Model optimization group):

- Modality replacement analysis
- Simulation models library update according to the modality replacement analysis

Group 2 (Simulation framework development group):

- Tuning of the simulation framework to support the updated user and simulation models.

4th Week:

During the forth week all the members of the two groups will collaborate in order to achieve the proper functioning of the simulation framework. Modifications in modeling and simulation will be done if necessary. Testing and bug fixing of the whole framework will also be performed.

Benefits of the research:

At the end of the workshop a new user modeling technique using UsiXML language as well as an innovative technique for user models optimization using a multisensorial platform will have been introduced. A framework that performs simulation of virtual users in 3D virtual environments will also have been developed. Reports will also be produced describing in detail the work conducted during the workshop, the methodologies used and the solution to specific problems that will have been arisen.

The importance of the whole framework that will be developed is very significant as it would be used for the accessibility evaluation of real environments for people with different types of disabilities by simulating the tasks of the virtual users in the equivalent virtual environments.

Profile of team:

A. Leader (with a brief CV)

Dr. Dimitrios Tzovaras
Dr. Dimitrios Tzovaras is a Senior Researcher Grade B (Associate Professor) at the Informatics and Telematics Institute. He received the Diploma in Electrical Engineering and the Ph.D. in 2D and 3D Image Compression from the Aristotle University of Thessaloniki, Greece in 1992 and 1997, respectively. Prior to his current position, he was a senior researcher on the Information Processing Laboratory at the Electrical and Computer Engineering Department of the Aristotle University of Thessaloniki. His main research interests include virtual reality, haptics, computer graphics, 3D data processing, multimedia image communication, image compression and 3D content-based search. His involvement with those research areas has led to the co-authoring of over thirty articles in refereed journals and more than eighty papers in international conferences. He has served as a regular reviewer for a number of international journals and conferences. Since 1992, Dr Tzovaras has been involved in more than 20 projects, funded by the EC and the Greek Ministry of Research and Technology. Dr. Tzovaras is an Associate Editor of the Journal on Applied Signal Processing

Dr. Konstantinos Moustakas
Konstantinos Moustakas received the Diploma degree and the PhD in electrical and computer engineering from the Aristotle University of Thessaloniki, Thessaloniki, Greece, in 2003 and 2007 respectively. He has been a teaching assistant in the same department (2004-2007) and a visiting lecturer during 2008. He served as a reseach associate in the Informatics and Telematics Institute Centre for Research and Technology Hellas, Thessaloniki (2003-2007), where he is currently a post-doctoral research fellow. His main research interests include virtual reality, collision detection, haptics, deformable object modelling and simulation, 3D content-based search, computer vision, and stereoscopic image processing. During the last three years, he has been the (co)author of more than 40 papers in refereed journals, edited books, and international conferences. He serves as a regular reviewer for several technical journals. He has also been involved in eight research projects funded by the EC and the Greek secretariat of Research and Technology. He is a member of the IEEE, the IEEE Computer Society and the Technical Chamber of Greece.

B. Staff proposed by the leader (with brief CVs)

Nikolaos Kaklanis, MSc
Nikolaos Kaklanis is a PhD candidate at the University of Surrey, UK. He received the Diploma in Information and Communication Systems Engineering from University of the Aegean, Greece in 2005 and his Msc in Advanced Communication Systems at the Aristotle University of Thessaloniki in 2008. His main research interests include 3D virtual environments, data mining, haptic and multimodal user interfaces. His involvement in these research areas has led to his participation in the authoring of 4 papers in international conferences. He is a contributor in the development of UsiXML and the developer of the “3D HapticWebBrowser”, an application that gives blind users the opportunity to navigate through the internet by touch.

Athanasios Tsakiris, MSc.
Athanasios Tsakiris is a Research Associate in the Informatics and Telematics Institute. He received the Diploma in Computer Science from the Aristotle University of Thessaloniki, Greece and the MSc in Computer Games Technology from the University of Abertay Dundee, UK in 2000 and 2001 respectively. His main research activities include 3D rendering, VR/AR/MR technologies and applications, Multimedia Authoring and Multi-modal Human-Computer Interfaces. His involvement in these research areas has led to his participation in the authoring of 2 articles in refereed journals, 2 papers in international conferences and the co-authoring of 1 book chapter. Thanos Tsakiris has been involved in more than 8 projects, 4 funded by the EC and 4 funded from Greek Secretariat of Research and Technology.

C. Other researchers needed (required expertise for each)

In general, researchers with strong background in all areas of the project will be needed. Priority will be given to:

- **User & Task modelling:** PhD student(s) or researcher(s) with experience in user and task modelling.
- **Machine Learning**: PhD student(s) or researcher(s) for training and parameterizing the user models with real measurements.
- **Virtual 3D modelling and virtual 3D interfaces:** PhD student(s) or researcher(s) with experience in virtual 3D modelling and virtual 3D interfaces.

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