A tool for assessing elderly drivers with MCI

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Abstract: Old people need to stay independent and mobile, thus driving their own car is of key importance to them for sustaining their quality of life. Several studies have connected the driving ability with autonomous living capabilities. However, since driving is a demanding task that requires multiple skills, a through fitness to drive assessment is an absolute necessity, especially for elderly drivers with cognitive impairments. Within IN LIFE project, a novel car driving ability assessment and enhancement web tool that aims to assess and prolong safe driving for the elderly with mild cognitive impairments. The tool consists of three tiers; the first tier includes the initial assessment questionnaires, while the second tier comprises the neuropsychological assessment part that identifies specific deficits in attentional functioning. Finally, the third tier contains a set of on-road tests. In addition, a consultation service is included that provides information on driving aids that are appropriate for the elderly. In addition to the web tool, a mobile application has been developed. The web application of the tool is based on a standard HTTP web server (Apache 2.4) and the implementation (front-end component) or else the Graphical User Interface is based on HTML, CSS, JavaScript and JQuery. The mobile application is based on Android platform.

Key-Words: driving assessment tool, computerized tests, elderly drivers, drivers with MCI.

1 Introduction

Currently, roughly 30% of elderly with dementia live alone and this figure diverges according to the type of the cognitive impairment of each elderly group [1]. However, most elderly people with cognitive impairments want to live independently for as long as possible. According to [2], by 2050 the number of people aged 80 and older will most probably triple in the OECD countries and a third of the population will be older than 65 years. Thus, an immense rise of the people who want to be independent and stay mobile is expected. Several studies have connected the driving ability with autonomous living capabilities. Also, the large increase in the number of elderly drivers holding a driving license highlights this population's need for independent mobility. Autonomous Mobility (e.g. ability to undertake more outdoors leisure activities and social visits) is strongly related to Psychological Well-Being.

Mobility is an essential attribute of quality of life in older people [3]. The restriction of mobility can lead to a decrease in social activities and in turn to an impairment of cognitive status [4]. Cognitive impairment is service delivery employing. Loss of cognitive functions, abilities and capacities may be further intensified by other age-related conditions which affects all domains of an individual's life and causes not only memory-specific barriers but also age-related, such as limitations of mobility, visual and hearing impairments (e.g. macular degeneration and chronic diseases such as diabetes, Parkinson's disease, Huntington's disease, chronic pain). The vast majority of elderly living alone do feel lonely and this could be really linked to loss of functionalities, with subsequent loss of independence and isolation.

2 The need of a driving assessment system

For many years, the identification of drivers at risk has been performed through a purely clinical approach. Individual cases were examined using standardised tests, generally focusing on visual acuity because it is very easy to test it, thus it is the most used sensory modality in driving. But

scientific studies have shown that classical visual tests have been proved not to be sufficient for measuring driving fitness [5]. In the same way, common medical examination does not allow distinguishing safe from unsafe drivers, because it is not sensitive to cognitive decline which seems to be more related to driving problems.

Driving is a demanding task, in which experience, sensory/visual, motor, and cognitive skills are highly involved. However all these skills are affected by age, but with different degrees of deterioration per person. This fact proves the necessity for a thorough driving assessment.

Usually older (experienced) drivers have learned to compensate their functional deficits by applying strategies such as driving with lower speed, driving only with daylight where visibility is good, etc. Still, not all drivers apply such strategies sufficiently or at all, and strategies may fail in complex situations. Hence the assessment of on-road driving appears to be necessary.

The need to have reliable and validated assessment procedures of fitness to drive is internationally recognised. An OECD report emphasises the importance of the evaluation of functional abilities of drivers [2]. According to it, fitness to drive assessment procedures need to be clearly defined, as well as training and re-training programs. The ageing of the European population further stresses the necessity for a fair and valid assessment system for older drivers.

2.1 IN LIFE project

IN LIFE is a H2020 project that contributes to the early recognition and effective mitigation of a number of ageing-related psychological risks (stress, insecurity, isolation, depression, etc.) which can eventually lead to physical and mental decline. IN LIFE aims to extend and support the independent living of seniors with cognitive impairments, through interoperable, open, personalised and seamless ICT solutions that support home activities, communication, health maintenance, travel, mobility and socialisation tasks, with novel, scalable and viable business models, based on feedback from large-scale and multi-country pilot applications. All the services are connected and communicate through a common platform, namely the IN LIFE application centre.

The project's aim is approached through the following objectives:

- To connect a wide range of adaptable ICT solutions for elderly with various cognitive impairments, into a common open reference architecture, to allow their interconnection and enhance their interoperability.
- To instantiate applications, services and business models to different geographical and sociocultural backgrounds, user group types (i.e. early dementia, moderate dementia, etc.), as well as lifestyles (i.e. living at home alone or with spouse, living at an elderly home, traveling, etc.).
- To provide tools and systems for services adaptation and personalization, to meet the different needs and wants of each individual in a dynamic way, allowing services to evolve together with the users' health and condition.

3 Driving assessment tool

The driving ability assessment tool forms part of a travel support system that is composed of 3 different and independent tools that have been realized in IN LIFE, in order to support the mobility of the elderly with cognitive impairments. The remaining tools are the Trip planning and routing support (while driving) and the Public Transport support. Altogether, the different tools aim to cover the travelling needs of older citizens with cognitive impairment for different transport modes (private and public) and the process of defining, setting the specifications and integrating the modules into the IN LIFE platform. The overall system functionalities were defined and specified with regards to the platform envisioned functionalities, architecture and structure.

3.1 Tool design and architecture

Driving-relevant cognitive functions can be measured with paper and pencil tests or better with computer-based psychometric tests. Tests of visual attention, even simple number cancellation tests, are highly predictive of older drivers' accidents. Finally, on-road tests in real traffic conditions are necessary to assess fitness to drive, as explained above. All these facts have been taken into account for designing and building the driving assessment tool. The tool is based on a previous project called IN LIFE, where a modular stepwise assessment procedure was proposed [6].

A three-tier architecture (Fig. 1) is used for the driving assessment tool and is composed of three major components. The first component is the server-side module (back-end application) that is responsible to serve the client requests.

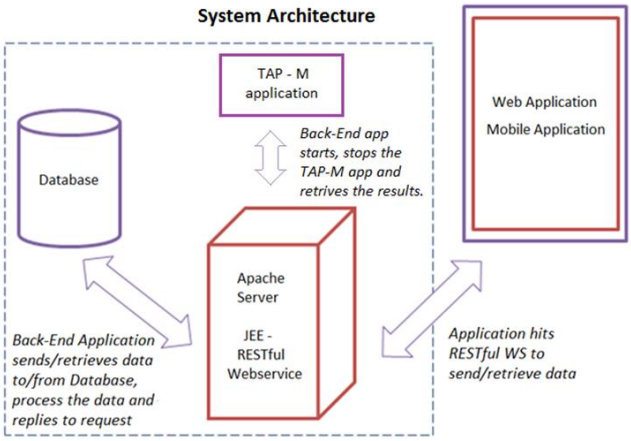

Fig. 1: Driving assessment tool architecture.

The server-side component implements the service operations. Additionally, the server-side component communicates with the database and/or an external tool like Test of Attentional Performance - Mobility (TAP-M) application that has been implemented by a company in order to send requests, retrieve data and maintain consistent the data stored in database. The server-side module has been implemented as a RESTful web service.

The tool is able to start/stop the TAP-M the application and finally retrieve the data exported by the application in xlsx format. Moreover, it implements the algorithms that determine whether the user is capable to drive the car or not. The server-side module defines also web services for communication with the main IN LIFE architecture and the Graphical User Interface. The tool implements procedures in order to preserve the data privacy and the management of users by the formal carers.

The second component is the relational database schema that is used to store the data related to tier1, tier2 and tier3 activities. The database schema of Fig. 2 stores data about:

- Questionnaires/surveys
- Questions
- Possible answers for each question
- Dependencies between questions
- The value type allowed for each question (e.g. Integer, Double, etc.)
- Users
- User's answers
- User's score
- User's role
- Event logs and types

Finally, the third component is the web/mobile application (front-end component or else Graphical User Interface) through which the user interacts with the tool. Regarding the web application, the tool includes five tabs. The first tab (called APP CENTER) takes the user to the main IN LIFE Application Center, while the second tab (called 1st TIER) contains the questionnaires related to TIER 1.

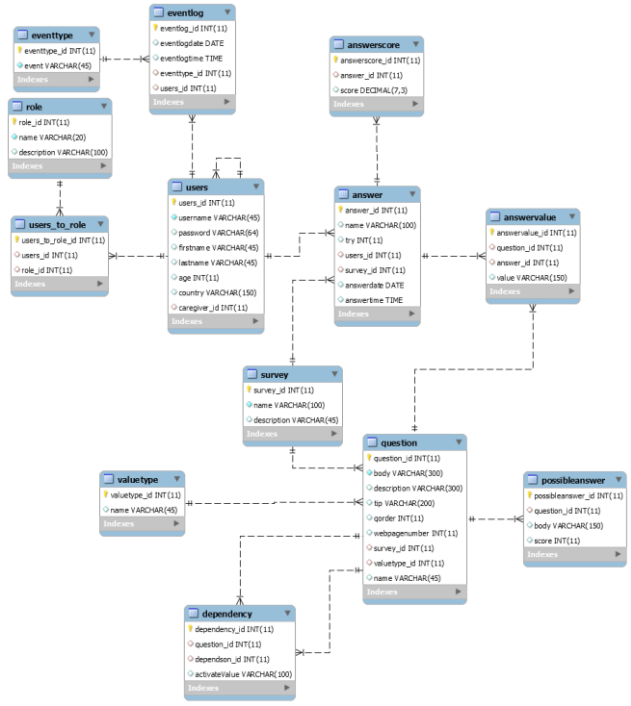

Fig. 2: Driving assessment tool architecture.

3.1.1 Software and/or hardware

The web application of the tool is based on a standard HTTP web server (Apache 2.4). The implementation of the web application (front-end component) or else the Graphical User Interface is based on HTML, CSS, JavaScript and JQuery which is a light weight JavaScript library. We also used a simple, free of charge, lightweight JavaScript API for handling cookies. Additionally, the web application uses the Asynchronous JavaScript and XML (AJAX) technique to send and receive data to/from web services.

The mobile application is based on Android platform. The tool uses the JavaScript Object Notation (JSON) format to exchange data between the web/mobile application and the web services. The same data format is also used by the tool to communicate with the IN LIFE application centre platform. The database runs on MySQL which is an open-source Relational DataBase Management System (RDBMS). The database schema consists of 13 relationally connected tables.

The web services are based on REST architecture (called RESTful web services). RESTful web services are light weight, scalable and easy to maintain and are very commonly used to

build APIs for web application. The web services are implemented with JAVA programming language with the use of Jersey library. The source code developed in Eclipse Integrated Development Environment (IDE). The web services are deployed on Apache Tomcat web server (servlet container) which is an open-source web server developed by the Apache Software Foundation.

Finally, the tool uses the Test of Attentional Performance - Mobility (TAP-M) application.

Only the healthcare professional has access to the data obtained through the driving assessment tool and they are anonymised (user code instead of name is used) and only they know to which name the user code belongs to. Therefore, patient/client privacy is not violated. Privacy is protected and data entry is anonymised.

3.1.2 Accessibility

The tool is based on web technology, JAVA programming language and the TAP-M application. Users require a web browser (better user experience using Google Chrome and Mozilla Firefox), an Internet connection, the JAVA installed in their PC and an installation of TAP-M application.

The tool is accessible through web browser. In case of execution control and neuropsychological estimation, the user has to use the TAP-M application.

Accessibility through a mobile device (smart phone or tablet) is provided, through a web browser. Additionally, there is a mobile application that can be accessed in Android based smart phones or tablets. However, the mobile application has limited functionality, since it provides only the user's assessment.

3.2 Tool specifications and functionality

The car driving ability assessment and enhancement tool has been developed and integrated on the IN LIFE platform. The tool developed by CERTH/HIT is divided in three major tiers and a consultation service that provides information on driving aids that are appropriate for the elderly, namely:

- Initial assessment questionnaires (Tier 1)
- Neuropsychological estimation (Tier 2)
- Road tests (Tier 3)
- Consultation on the available driving aids

If the user fails in the first tier, then proceeds with the second tier and if the user also fails in the second tier, then he/she goes to the third tier. In case the user succeeds in the first tier then he/she does not follow the next tiers. The same applies in case of successful completion of tier 2.

The core modules of the first tier are given next:

- A module that implements and manages the questionnaires.
- A module that starts/stops the TAP-M application and retrieves the results.
- A module that implements an algorithm that computes the overall score.
- A database module that stores the users' questionnaires answers and results.
- A module that provides web services to IN LIFE APP Center.

The core modules of the second tier are listed below:

- A module that starts, stops the TAP-M application and retrieves the results.
- A module that implements an algorithm that computes the overall score.
- A database module that stores the results obtained by the TAP-M application.
- A module that provides web services to IN LIFE APP Center.

The core modules of the third tier are:

- A module that implements and manages the road test checklist.
- A module that implements an algorithm that computes the overall score.
- A database module that stores the checklists, the answers and the results.
- A module that provides web services to IN LIFE APP Center.

The core modules of the driving aids component are the following two:

- A module that presents and manages the driving aids.
- A database module that stores the driving aids.

3.2.1 Tier 1: IADL questionnaire

In this tier, the Instrumental activities of daily living questionnaire (IADL) has been implemented, which is the initial assessment of the system. For using it, the system user (i.e. a formal caregiver, driving assessor, clinician, etc.) has to define the username of the elderly and the test number. Each user can manage only the elderly drivers data for which he/she is responsible and can fill in, edit, remove, view or print a questionnaire (Fig. 3).

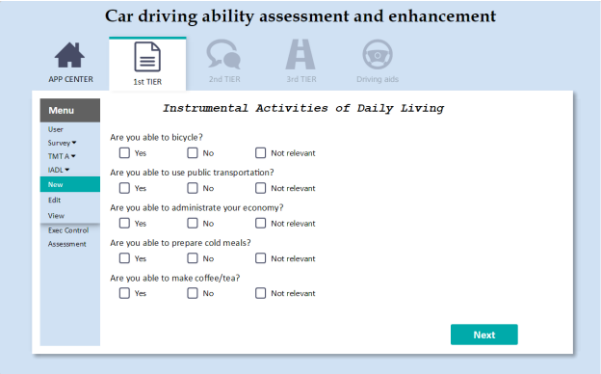

Fig. 3. Instrumental activities of daily living questionnaire

Each tab contains also an assessment section where the tool presents the overall assessment of the current tier (Fig. 4). The web/mobile application hits RESTful web service to send and retrieve data.

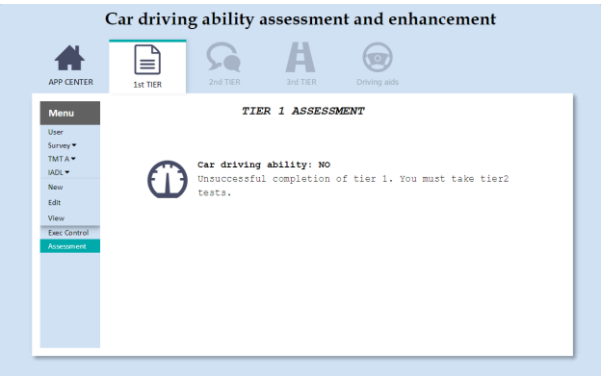

Fig. 4. Tier 1 assessment.

Furthermore, suggestions for using specific driving aids are provided to the elderly driver, if needed. Data is stored in a database that is also used as a pool by the 'Driving aids' section, as described in section 3.2.4.

Fig. 5. Consultation on appropriate driving tools.

3.2.2 Tier 2: Neuropsychological tests (TAP-M)

The 2nd Tier provides the functionality to start and stop the TAP-M application in order the user to accomplish the neuropsychological tests. Then, the user has to press the image button 'Score' (Fig. 6) so that the tool retrieves the results produced by the TAP-M application and computes the car driving ability assessment.

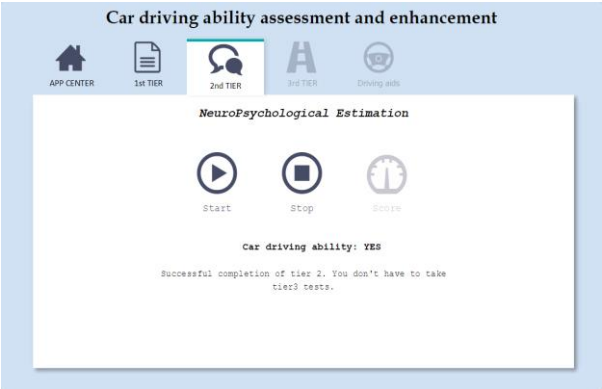

Fig. 6. Tier 2 assessment

The on-road test (see Tier 3 below) is closely connected with prior assessment of those neuropsychological functions which are relevant for safe driving. The neuropsychological assessment tool identifies specific deficits in attentional functioning.

3.2.3 Tier 3: On-road tests

The 3rd Tier contains the questionnaires related to the on-road tests that the driver has to take. In specific, four questionnaires related to road tests are included, as well as assessment link that presents the overall assessment.

The first and second tabs are always active and the user can interact with them, while the third, fourth and fifth tabs are inactive when the user logs in. The third tab becomes active if the user fails Tier 1 and the fourth tab becomes active if the user fails the neuropsychological tests of Tier 2.

3.2.4 Driving aids

Through this section, the user can access a database with driving/support aids that are appropriate for elderly drivers. For each aid a short description and photos/explanatory images are provided. Relevant screenshots follow below.

Fig. 7. Driving aids screenshots.

3.3 Mobile application

Except from the web application, the car driving ability assessment and enhancement tool includes also a mobile application. The application has limited functionality and it is an informative system. The user can be informed about either the overall assessment results or the assessment scores in each of the three tiers.

Fig. 8. Driving ability mobile app screenshot.

4 Conclusion

Fitness to drive should be viewed as a public health related issue instead of only as a road safety issue. Car driving is synonymous with independence and an active life.

The advantage of the IN LIFE driving ability assessment tool is that it takes into consideration the right of mobility for all, that it takes advantage of the greater experience of elderly drivers who are often able to compensate their deficits. The developed tool promotes the right of mobility. It balances between sensitivity (during the first tier using the screening battery) and specificity (during the latter tiers of the procedure, using the in-depth assessment battery). In conclusion, the assessment of fitness-to-drive is part of an integrative process to determine if an elderly driver with MCI can hold his/her driving license. It is not limited to the assessment of residual capabilities.

The potential economic impact of IN LIFE for Europe is huge as the elderly ('silver') market (i.e. products and services for independent living, home care and mobility) represents an enormous business sector, which currently is highly concatenated in terms of individual-regional markets, as well as independent-focused micro services.

Currently all the modules of the travel support system are under evaluation, with 150 elderly drivers. The tests are taking place in Thessaloniki, at the premises of the Hellenic Institute of Transport. with the overview of a driving instructor and a psychologist. Final adaptations to the modules are expected, once the user's feedback is available.

Acknowledgement

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