Thesis Proposal for Mobile Application for Intraoperative Naming Test for National Languages of Russia

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***Abstract* — Speech is one of the cognitive functions central to the person's life quality. However, it can be damaged as an undesired side-effect in brain surgery if the surgery site includes areas of the brain active in speech. One possible solution to the problem of language preservation after such surgeries is intraoperative language mapping, which can be done with the help of a naming test. This procedure is fairly new and the specific instruments to conduct it are being developed currently, with preference for technologies and protocols that allow automation and flexibility of the procedure. This paper describes the proposition and development of one such solution, specifically a multiplatform mobile application for automated language mapping with naming tests in several languages common among the citizens of Russia.**

***Keywords* — language mapping, automated testing, naming test, mobile application, platform-independent mobile development**

I. Introduction

Speech is undoubtedly one of the most significant cognitive functions, with the effects of communication disabilities being devastating [1], [2]. Unfortunately, such negative effects often follow surgical treatment of brain tumours. In order to minimise the damage to the linguistically eloquent cerebral areas, the procedure of intraoperative language mapping with direct electrical stimulation is often used during such surgeries [3], [4].

Historically, object naming has been one of the most widespread tasks to be offered in language mapping, arguably being more effective, compared to the alternative of, for instance, counting tasks, since the latter is associated with automatised language, while the former is propositional [5]. The significance of this difference lies in the fact that propositional language reflects naturalistic language use and is represented by brain areas which have more linguistic relevance and thus should be preserved. Importantly, object naming is also a fairly simple procedure, in contrast to more sophisticated linguistic tests, which is advantageous with the tests being conducted in the circumstances of operation rooms.

Although the language mapping with use of object naming is a commonly used procedure, only a few standardised tests have been published, one of them being the Russian Intraoperative Naming Test, developed by a team of experts from National Research University Higher School of Economics, Moscow, Russia [6]. This test consists of a standardised

protocol and a database of carefully selected stimuli for naming in the Russian language. As suggested by the conducted research, the test proved to be effective in preservation of language function in test subjects who underwent brain surgery. The main stages of the testing are the following: selection of the tests depending on the tumour's location, preoperative testing, selection of the tasks for intraoperative testing from the ones done successfully by the test taker in the previous step, the intraoperative testing itself and the final stage of result analysis.

Despite the active and fruitful application of the Russian Intraoperative Naming Test, since its publishing in 2016, it has been conducted manually, which presents challenges both in the procedural aspect with the necessity of using several devices for presenting stimuli and recording the test subject's answers, and in the scientific aspect by requiring additional effort in the results' systematisation and analysis. As some of these issues could be potentially solved by conducting the test with the help of specific software, designed to digitalise the test, the proposition of this paper is the development of such software.

II. Proposed solution

Having discussed the current approach to object naming tests in language mapping, this paper proposes a project with the aim to automate the procedure. The proposed way of addressing the issue is the development of a mobile application which will fully incorporate in digital format all the essential stages necessary to conduct language mapping, namely the preoperative and intraoperative tests and the assessment of the former, as well as other helpful functions, such as the input and storage of the test subject's personal data, selection of tests for the participant, etc.

A substantial addition to the existing solution is the introduction of languages apart from Russian in the test. As it is crucial for the test to be conducted in the participant's mother tongue, it has been decided to provide test takers who are bilingual native speakers of national languages of Russia with tasks in their native languages, as well as in Russian in order to enhance the precision of the language mapping. Consequently, the application will contain stimuli selected for other languages, but will only focus on the object naming test, since other types of tasks are not yet standardised for other languages.

III. Approach

The proposed project will be carried out at the Center for language and brain of National Research University Higher School of Economics under the academic supervision of the experts from the Center. As the project objective lies in the domain of software development, the methodology applied will be similar to the traditional process of application development. Firstly, extensive analysis of the scientific domain and existing solutions will be conducted. In order to precisely determine the operation standards and limitations of the application, the research of methodology, best practices and their reasoning of the original test is necessary, and it will be carried out prior to other stages of work, so as to create the exact tool that is required.

The following stage will consist of the thorough requirements engineering process, including the definition, negotiation and structuring thereof. Although the functionality of the application is rather easily determined from the original test, it is still essential to formulate it precisely and understand the potential modifications that will be necessary to adapt the procedure to the digital format. This stage shall result in the composition of the Requirements document in the version agreed on by all the parties involved.

Next, research and comparison of the technological stack will be conducted, during which the most suitable frameworks, tools and practices will be chosen for the goal of the project. There are few requirements regarding the technology used in the project, specifically that the application is written in the language which will easily allow it to be cross-platform. Xamarin Forms framework was chosen as such language, therefore all the other technological choices will be based on the choices available for this framework.

Once the requirements and tools are agreed upon, the workload planning is to be done. To keep the development flexible, reactive and client-oriented, it is decided to apply Agile methodology to the work process. Also, a key principle in this project is the continuous communication and consulting with the clients and scientific advisors with the aim to keep the product useful. In accordance with the aforementioned principles, an approximate work plan should be arranged with workload distributed evenly until the project submission.

The central and the most time-consuming part will be the actual development of the software piece, consisting of specific blocks, dedicated to the parts of functionality that will be worked on. The development will generally follow the path of specification, starting with the most general structures of the program's logic and ending with the finetuning of the most specific ones. As well as this, adjustments motivated by the client's feedback should be made.

Then, extensive testing will be carried out to ensure the reliability and quality of the application. As the application is to be used in a medical environment with the test takers' quality of life depending on it to some extent, the scrutiny it will be subject to must be intense, therefore the testing phase will be thorough and lengthy. Finally, the documentation block should be developed, to ensure the easy maintenance of the software piece after its submission. In these steps, the proposed project should be finished.

IV. Chosen technology

In accordance with the outlined requirements, the solution must be a cross-platform mobile application, suitable for Android and IOS platforms alike. To satisfy this requirement and ensure further supportability of the application it was decided to carry out the development in the Xamarin Forms framework in C# language [7]. In comparison with alternative options for cross-platform development such as, for instance, Kotlin Multiplatform Mobile, Flutter and React Native, Xamarin Forms is a more mature framework with a detailed documentation

base and wide range of solutions, which are of sufficient quality for the purpose of this project.
GitHub is chosen as the version control system due to its convenience, reliability and flexibility.
Finally, as the instrument for task control Kaiten [8] was chosen instead of the more popular Trello service due to its higher stability.

V. Architecture

In order to avoid developing an unnecessarily sophisticated system, diligent architecture research has been carried out. The system being cross-platform, it consists of three modules, namely the shared general module, an IOS and an Android derivatives. By virtue of Xamarin's flexibility the system is defined mostly in the general module, which is afterwards translated for IOS and Android automatically.
The proposed design for the shared system follows the MVC pattern [9] and contains Model classes in C# that represent entities of the procedure (a Stimulus, a Test, a Patient, etc., shown in Fig. 1), View classes in xaml that determine the layout of the application pages (PatientPage, ProbeCheckPage, TestPage, and so forth) and corresponding Controller classes in C# that define the behaviour of the view elements. Importantly, to achieve easy extension of the project by the addition of other languages, linguistic resources are linked as embedded resx files, which are essentially data tables. Such data linking allows future introduction of various other datasets.

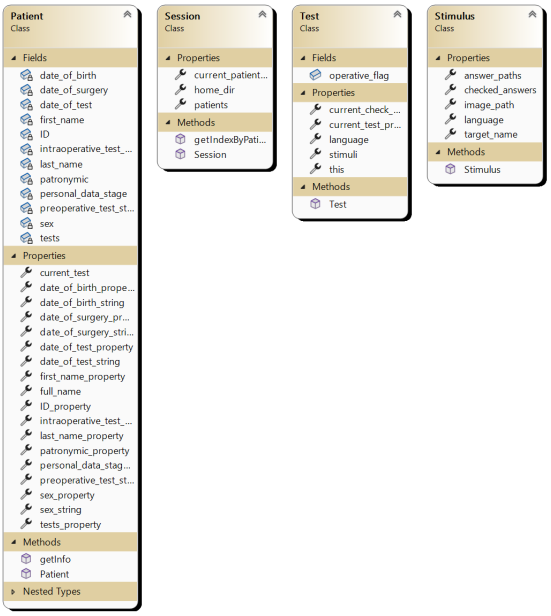

Fig. 1 Model class diagram, representing the types of modelling objects that participate in the testing.

VI. Current stage

As of the date of the present report all the necessary preparatory research and design stages have been completed and the baseline of the application has been developed. To be exact, the Model is fully implemented in code, resources fully added and the general logic of the system is defined.
In terms of the application functionality, currently it supports input of the patient's information and its storage during the session, choice of languages for the testing, assembling of stimuli set for the test, presentation and checking thereof in the preoperative testing protocol.
As for the further work in the nearest future, the remaining necessary functionality needs to be finalised, such as data storage in the device memory, associated audio recording and saving, showcasing of stimuli in the intraoperative testing mode, and data export in convenient formats. Additionally, some

extra features that will be introduced include audio recordings' compression and uploading patients' data into the application from external sources. Also, possible fine tuning of the general application module may happen for IOS and Android separately to ensure its peak performance and user experience on both platforms.

VII. Conclusion

The solution that exists at the current moment is minimally viable, as it can perform certain procedures and fulfils the most important of the requirements, however it still lacks more specific functionality, such as, for example, flexible data export. That is the reason why further work and development is required and will be carried out in the following months. When the project is finished, it will become a powerful tool that supports many procedures and allows its users flexibility in their work.

The author dares to hope that the developed application, apart from having obvious practical value of allowing easier automated speech mapping and potentially making the test procedure more common as the result, might also be valuable in scientific use, as it will provide the researchers with structured, recorded data of the tests in multiple languages. This data, subsequently, can be used to propose theories and draw conclusions regarding the efficiency of object naming procedure, language representation in the brain and, possibly, correlation in neurolinguistic phenomena between different languages in bilingual participants.

Hopefully, the development of such software for the Russian Intraoperative Naming Test will encourage the development of digital solutions in other languages, thus promoting language mapping, which can sufficiently improve the rates of language preservation in patients with surgically treated brain tumours.

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