KomSim – Speech Rehab for Aphasia

Thomas K. Hansen, Resource Center for Integration, Vejle, Denmark.
Niels Thybæk-Hansen, Dansksimulatoren Aps, Odense, Denmark.
thkha@vejle.dk
nt@gxm.dk

Abstract:

The Communication Simulator (KomSim) (www.komsim.dk) project addresses the development of a serious games platform, a therapeutic, interactive, online language and speech rehabilitation tool, initially aimed at the 15 – 20.000 people in Denmark who annually suffer neurological impairment with ensuing aphasia, defined as a decrease in the ability to use language, due to an apoplexy from stroke, cerebral hemorrhage, clot, or other brain trauma. Initially, the main target groups are 1) those suffering from impressive or expressive aphasia 2) the dysarthric sub-group and 3) those with cognitive behavioral impairments.

The KomSim platform is a spin-off of www.dansksimulatoren.dk, (DanSim) an online language and culture learning platform developed for immigrants needing to learn Danish, which uses speech recognition for communicative interaction and a 3D game environment. In the game the learner has to use the acquired language and culture skills to navigate a named city in Denmark and complete the overall mission of finding a specific UNESCO heritage site, the Jelling Mounds.

The KomSim platform is developed based on DanSim's Speech Technology, in collaboration with a group of speech-language therapists (SLT) from the Center for Communication and Welfare Technology (CKV), Vejle Municipality, The Resource Center for Integration (VIFIN) and Dansksimulatoren Aps. The project began in October 2013.

The overall aim of the KomSim platform is to provide therapists and patients with a helpful and motivational tool through which a more targeted, more intensive and rigorous rehabilitation regiment can be implemented. KomSim is built incrementally beginning with a basic skill section, then in depth scenarios concluding with 3D scenes, yet to be formally defined. The skill sections will be gamified in a traditional PBL style – points, badges and leaderboards, whereas the scenarios will be scored on a more elaborate basis.

Keywords: Serious games, aphasia, rehabilitation, speech recognition, speech therapy.

1. Introduction

Aphasia, *a reduced ability to use language*, is usually the result of a blood clot or hemorrhage in the brain, causing damage to the speech and language centers, also known as Broca and Wernicke's areas. Aphasia is classified as either *expressive* meaning an inability to express oneself verbally, or *impressive*, indicating that the patient has problems understanding language. A patient suffering impressive aphasia will also experience expressive aphasia, but not necessarily vice versa.

Dysarthria is an aphasic speech disorder where the language itself is still intact, but the patient is experiencing severe motor-mechanical problems when attempting to articulate sounds and words.

An additional impairment not necessarily related to speech is Cognitive Behavioral Impairment, where the patient has lost the ability to act correctly in social situations, for instance loosing the concept of being polite.

An average of 20.000 people in Denmark annually suffer brain trauma causing massive effects for patients, family and society.

The patient experiences a decrease in quality of life due to physical and mental manifestations of the trauma. The patient's family experiences mental distress, helplessness and sorrow given the altered circumstances for spouse, children and family and society measures a significant increase in health care expenditure. The aim of *KomSim* is to positively address and affect all three mentioned areas, described in section 2.

75% of the 20.000 patients are from apoplexy, clot or hemorrhage, and 25% from other brain trauma. Of the 15.000, approximately 12.000 cases are first time victims and 3000 are repeaters. The current statistics show that the average number of incidents remains nearly the same, albeit with an increasing rate of survival given faster response times, better treatment, etc.

It is estimated that as of January 2011, a total of 123.000 people live in Denmark suffering the effects from apoplexy or trauma.

The annual budget for the treatment of brain trauma is 650 million Euros. This corresponds to an average cost in health care of 25.000 Euros per patient for the first year, and 40.000 Euros over the next three years. The listed expenses are an average and vary depending on the age of the patient. The age group 18 to 25 suffering severe trauma comprises 40 people a year, but costs between 350.000 and 850.000 Euros/year, whereas the 6+ group suffering light to moderate damage, costs 10.000 Euros/year.

The approximated expenses per year of 25.000 Euros per patient are divided into 10.500 for the hospitals where the initial treatment takes place, 7.500 for the municipalities that take over the rehabilitation process following discharge from the hospital. The remaining 7.000 Euros are an estimated loss of productivity, income for society).

2. The Rehabilitation Process – the Essence of Time
Typically, in the acute phase, a patient suffering a trauma will be admitted to the hospital where a therapist will conduct an initial examination and assessment of the patient's language faculties, hereafter slightly incorrectly referred to as a *diagnosis*. The diagnosis has the purpose of determining a proper rehabilitation process for the patient following initial treatment. After the acute phase is over, the patient is typically admitted to a live-in rehabilitation section or in-home treatment at one of the regional Communication centers, for which the patient is picked up by taxi and driven back and forth.

Live-in rehabilitation typically comprises physical therapy as well as speech and language therapy. The latter will usually be one hour a day or every other day. Live-in rehabilitation is often of a lengthy character, up to 4 months for instance. Upon dismissal from the facility the patient will most likely be enrolled in an in-home treatment program, similar to the less affected patients
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In-home treatment typically takes place 1-2 times a week, lasting 1-2 hours, either on an individual basis or in smaller group sessions. Patients are transported to and from their respective homes via taxi. All costs are covered via public funding and patients are dismissed from further rehabilitation when it is concluded that no further, or only minimal, development is possible. It is however still possible for the patient to participate in a compensation program organized by the municipalities. This could typically be equivalent to 1 group session a week, lasting 2 hours for 6 months.

Although specific scientific studies and evaluations concerning the rehabilitation effort are a rarity, the Medical Technolgy Evaluation 2011 states than an overwhelming number of consulted sources stress that all experience shows that an early and highly intensive rehabilitation effort, which can further benefit from family involvement, is critical in order to achieve *a good result for the patient and a better quality of life*, thereby hopefully also providing a quicker and better path for the patient on the road to recovery and re-integration into (working)-society.

KomSim intends to facilitate all aspects of the process. The speech-rehabilitation program used by the patient through KomSim, is designed by the SLT for the specific patient and will allow the patient to train as much as he or she can manage. Also, the SLT does not need to be present during most sessions as family members can be relied upon to assist patients, in particular those with accompanying physical impairments, thereby also integrating the families more in the process. A log-function is integrated so the patients results are visible to the SLT, who can then change the content of the rehab training as desired. This allows the SLT to continually monitor the patient, also from afar, but also provides hitherto unseen amounts of training data which can be analyzed and used as evidence, something which is often called for in the literature.

The increased opportunity of rehabilitation in this area will hopefully be reflected in shorter commitment times at the hospitals, less taxi-transportation, which has the disadvantage of tiring the patient as travel requires a lot of mental energy, and quicker integration into working society in one form or another.

3. The DanSim – KomSim relation
The Danish Simulator (Hansen, 2013 – Hansen & Petersen, 2012) consists of 3 separate, but interdependent, sections, 1) The Pronunciation Trainer (PT), 2) the Skill Builder (SB) and 3) the Game Environment (GE).
The purpose of the PT is to enable the foreign learner to acquire vocabulary words, while simultaneously identifying pronunciation mistakes at the level of the individual sound/phoneme. This means that every time the learner mispronounces a word the PT's built in speech Recognition System attempts to identify where the

mistake was made (see Figure 1.) and gives the learner a list of words containing the specific sound which the learner should practice.

It should be mentioned that the feedback is given to the learner by the game'ss main character, the old Danish King, Harald Bluetooth.

Figure 1. King Harald does not understand you and tells you so.

The purpose of the SB, which can also be compared to an interactive book, is to teach the learner single words and sentences as well as the specific necessary cultural knowledge as it relates to Denmark (see example in Figure 2). The SB section also subjects the learner to multiple exercises throughout the training material, as well as an end of level quiz that tests if the learner has acquired the intended knowledge and is ready to continue. Based on the results of the learner, the DS gives a recommendation as to the best path forward for the learner.

Figure 2. When do Danes hug and say goodbye?

The GE provides the learner with a 3D environment to explore and where to use the knowledge and language acquired in the PT and SB in a realistic fashion in order to accomplish a given set of tasks. For instance, the learner, having just gotten of the train in Vejle city, needs to find a local café where Peter, a friend from long ago, waits with a colleague of his. Here Bob, the main character, has to remember how to greet Peter verbally, but also to choose whether to shake hands, hug or do nothing at all, whichever is appropriate in the given context (Figure 3).

Figure 3. Meeting people. What to Say? What to do?

The overall idea in the development of DanSim into KomSim, which obviously requires a great deal of adaptation and restructuring, is that the KomSim platform is useful to all three aforementioned groups of aphasics, dysarthrics and behaviorally impaired, but also that each segment as described in relation to DanSim can provide the client with a training method specific to their need. The dysarthrics will get a lot of help and audiovisual hints concerning their problems in the PT; the aphasics will benefit from the great amount of training words and categories in the SB, and the behaviorally impaired will get a chance to train and test their situational awareness in the GE.

4. Current KomSim Status

Since October 2013, SLTs, linguists, engineers and programmers have been working on developing the KomSim platform demonstrator. Currently we have a platform where the SLT can enter the results of the diagnosis of the patient and accompanying dysfunctions, upon which KomSim provides a number of exercises for the patient to start working on. Exercises range from initially single words to sentences, currently concluding in a scenario depicting a *kitchen* (Figure 4) where the user has to demonstrate knowledge of vocabulary items, sentences and situational awareness, via all modalities, such as reading, writing, listening and speaking.
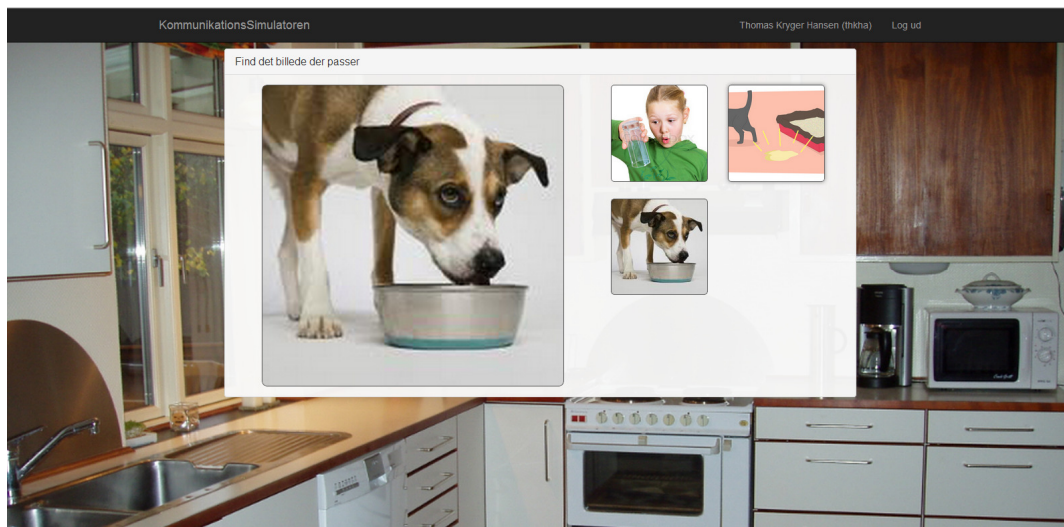
Figure 4. In the kitchen - match the picture you see.

The demonstrator has been available to SLTs for a month and feedback scheduled at a workshop in May 2014 will determine alterations for the next phase of development and the future course.

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