A Multi-lingual Decision Support Prototype for the Medical Domain

David Dinh

osTechnology Pty. Ltd.

Health Technology Solutions

david.dinh@ostechnology.com.au

Dennis Chan

PST Research Group

Voice Solutions Developer

dennis.chan@pstresearch.info

Jack Chen

PST Research Group

Health Solutions Developer

jack.chen@pstresearch.info

Abstract

In this paper, we are proposing a multilingual prototype that can effectively collect, record and document medical data in a domain specific environment. The aim of this project is to develop an electronic support system that can be used to assist asthma management in an emergency department.

1 Introduction

Speech technology has the ability to generate resource and time savings within a hospital environment. Recording and managing patient data from non-English backgrounds can be achieved successfully through the implementation of a multilingual voice system and a standardised electronic medical decision support system such as ACAFE (ACAFE 2006) described in Section 5.3. By implementing the ACAFE standardized protocols together with a voice system, we are able to assist in the first stage of the clinical pathway in the treatment and management of Asthma (see illustration of Stage 1 in figure 3).

In this demonstration description, we are proposing a multi-lingual voice system based on a standardized patient management system called ACAFE that can effectively collect patient data in electronic format. The combination of the two systems would make it easier to assist in the recording and documentation of vast amounts of information whilst overcoming communication and efficiency barriers. This data can then be aggregated and analyzed after the event to assist with clinical and performance measures. This makes effective use of emergency department resources while providing the emergency staff with immediate access to important patient information.

2 Objectives

To show how quality health care can be delivered in a complex multilingual hospital environment with the aid of an electronic decision support system such as ACAFE.

3 Demo Description

Our demo prototype integrates a voice recognition system together with the ACAFE system described in more detail in section 5.3. Our voice recognition prototype relies on data extracted from the standardized treatment protocols that have been based on research by ACAFE (ACAFE et al., 2006). These standardized protocols form the basis of our system-patient interaction to the medical sub-domain (Starlander et al., 2005).

Since our system is heavily driven by ACAFE, we have been able to minimize the requirement for an open range of questions that require translation. As a result, we only require the use of the grammar-based language model (GLM) that has been implemented using Nuance's speech recognizer (Nuance 2005), and not a statistical language model (SLM).

The standardized protocols require no manipulation or changes in tense as the ACAFE system is essentially a decision support tool. The flexibility of the decision support tool allows the clinician to make the final decision and vary any responses or inputs. Hence the range of questions our multilingual system poses to the patient is also standardized and limited. With the smaller set of questions it is feasible for translation to occur via direct ACAFE to 'target-language' mappings (subject language to many variations of a target-language).

The use of GLMs over SLMs for medical speech translation has been proven to provide higher translation accuracy (Rayner et al., 2004, Rayner et al., 2005). We expect that by combining the higher accuracy levels of recognition through the use of GLMs with a limited set of possible questions for a particular medical sub-domain, we can achieve an improved translation success rate.

Currently, our system requires the Overseer (such as a nurse) to specify the patient's native language (in our example Chinese Mandarin) and problem sub-domain (in our example asthma). From there, the Overseer can either speak a question as defined in the protocols contained within the ACAFE system (using English), or select one using the terminal. The question is then rendered using recorded audio (TTS is used as a fall back strategy) and played to the patient. Once the patient responds verbally or physically (e.g. nod of the head), the Overseer is required to enter that response into the system.

The Overseer is capable of viewing reports that detail a particular patient's responses prior to further analysis/treatment, or they can view statistical reports. As a proof of concept, the Overseer can generate a statistical report that details patient background precipitating factors (numbers of respiratory tract infections, cold weather, exercise and dust/pollens)

4 Suggested Scenario

The triage nurse will identify the patient's native language to enable the correct voice system translator. The voice system will translate the standardized asthma management plan questions into the patient's native language.

Patient will answer each question in their native tongue. The voice system will convert this information into the ACAFE system format. When each question has been answered, the ACAFE system will store the answers and the voice system will then follow through to the next ACAFE question.

Upon completion of the set of ACAFE based questions the voice system will then provide a review of the questions with answers in the ACAFE system in either English or the native language. A voice recording will also be stored to play back for future reference.

Triage refers to the answers that have been collated in the ACAFE system via the assistance of the voice system. This information can be understood by all emergency team staff as the voice system has translated the answers of the patient into English according to the standardized management answers.

The Emergency Department now has a pre-compiled list of patient information compliant with Stage 1 of the clinical pathway contained in the ACAFE system to help assist in the treatment of asthma, without having to worry about communication difficulties between patient and medical staff.

4.1 Demo script

Triage Nurse: "Hello, what pains or difficulties are you experiencing?"
Patient: "Understand English no good, asthma…"
Triage Nurse: "Can you confirm your language, Mandarin or Cantonese?"
Patient: "Chinese, mandarin."
Triage Nurse: "OK, what I will do now is use a special machine to ask a few simple questions, you can just answer yes or no, it will ask the questions in mandarin so you can understand better. OK, here we go… "
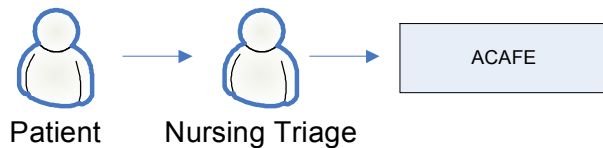Triage nurse then activates the voice system which goes through the set of ACAFE based questions in mandarin.

Figure 1: High-level view of user ACAFE interaction

5 System Architecture

5.1 Overview

Figure 2 illustrates a component view of the design for our prototype system. The Overseer acts as an overriding authority for the ACAFE Decision Support component, providing interpretations of the Patient's native language, medical problem sub-domain, and as a failover, the Patient's responses (both verbal and physical) to the questions asked.
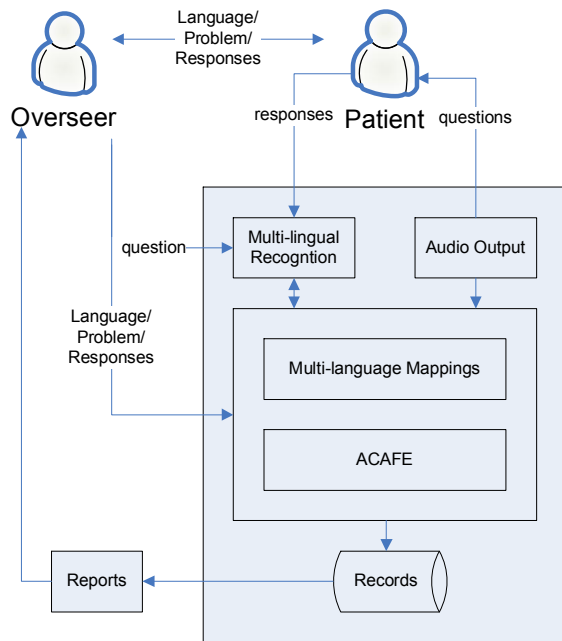

Figure 2: Component overview of the System Architecture

5.2 System Components

The following section outlines each component shown in the Overview diagram (Figure 2).

Audio Output – Renders questions (as required by the Decision Support) in the Patient's native language using recorded speech, or Text-to-Speech (TTS) if the recorded speech is not available.

Multi-lingual Recognition – The majority of questions posed to the Patient are in the form of yes/no questions. As such, the recognition of the Patient's utterance needs only to recognize basic responses in the Patient's selected native language.

ACAFE – Provided with the medical sub-domain (e.g. asthma/breathing difficulties), specifies questions according to a standard set of diagnosis questions.

Records – Records Patient responses to Questions (both textual and audio representations), final outcome, and statistics that are used for both individual Patient reporting and statistical reporting.

Reports – Provides individual Patient reporting (i.e. native language, medical sub-domain, responses to questions, and final outcome) and statistical reporting for the use of measuring the relationship between asthma and the precipitating factors.

5.3 Asthma Decision Support

ACAFE is an electronic interface for the Emergency Department that provides clinicians with a decision support tool to assist in the management and treatment of asthma. The system incorporates clinical decision support based on current evidence and guidelines that is simple to access, adaptable to the needs of the clinicians working in the ER and is capable of being integrated with existing medical databases.

The system's core focus lies in clinical pathways for the treatment of asthma. This is shown in Figure 3 below. A clinical pathway in the medical sense is a decision tree based on clinical assessment that guides the management and further investigation of a patient with a particular clinical problem. This decision tree has been based on consensus guidelines and institutional protocols based on the best available evidence for the management of asthma.

```
┌─────────────────────────────────────────┐
│        STAGE 1 – Patient History         │
│            Presenting problem            │
│      History of presenting problem       │
│       Specific asthma risk history       │
│           Medication, Allergy            │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│        STAGE 2 - Examination             │
│           General Appearance             │
│               Vital Signs                │
│         Respiratory Examination          │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│          STAGE 3 - Diagnosis             │
│            Working Diagnosis             │
│          Differential Diagnosis          │
│           Confounding Factors            │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│   STAGE 4 – Electronic Decision Support  │
└─────────────────────────────────────────┘
                    │
                    ▼
┌─────────────────────────────────────────┐
│      STAGE 5 – Final Assessment          │
└─────────────────────────────────────────┘
```
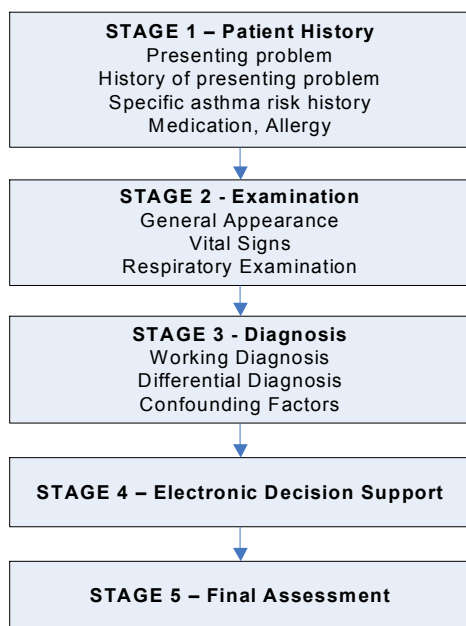
Figure 3: The ACAFE clinical pathway

In the ACAFE system the clinical pathway is represented by the information required to ascertain the severity of asthma to decide on a list of further investigations, consultations and medication orders. The clinical pathway outlines the means through which the system can advise the doctor on the optimal asthma management care plan.

At this stage, our voice system will be integrated with stage 1 of ACAFE's clinical pathway, in particular the history/information collection side of things.

6   Conclusion

We have shown that the ACAFE system with the assistance of our voice system can capture the information required to assist clinicians better manage the treatment of asthma in an emergency department. In capturing this data, the ACAFE and voice system incorporates the clinical pathways and decision support in the workflow of the doctor. In this demonstrator paper, we proposed a system that:

Relies on ACAFE by providing an electronic standardized protocol for the treatment of asthma.

Allows multi-lingual support thereby increasing communication between medical staff and patients during information collection and follow-up review after the patient has been discharged.

Increases efficiency by automating how information is collected by assisting in the recording and documentation of vast amounts of information while also streamlining the update of data electronically into the patient medical system.

Acknowledgements

References

ACAFE Research Project and Development team, http://www.ostechnology.com.au/acafe/our_team.html. As of January 2006

Nuance, http://www.nuance.com. As of 8 December 2005.

M. Rayner, P. Bouillon, N. Chatzichrisafis, B. A. Hockey, M. Santaholma, M. Starlander, H. Isahara, K. Kanzaki, Y. Nakao (2005). *A Methodology for Comparing Grammar-Based and Robust Approaches to Speech Understanding*, In *Proceedings of Eurospeech-Interspeech, 4-8, September, 2005, Lisboa, Portugal.*

M. Rayner, P. Buillon, B. A. Hockey, N. Chatzichrisafis, M. Starlander (2004). *Comparing Rule-Based and Statistical Approaches to Speech Understanding in a Limited Domain Speech Translation System.* In *Proceedings of TMI 2004, Baltimore, MD UA, 2004.*

M. Starlander, P. Bouillon, N. Chatzichrisafis, M. Rayner, B.A. Hockey, H. Isahara, K. Kanzaki, Y. Nakao, M. Santaholma (2005). Breaking the Language Barrier: Machine Assisted Diagnosis using the Medical Speech Translator. In *Proceedings of the XIX Internation Congress of the European Federation for Medical Informatics MIE, 28 August - 1 September, 2005, Geneva, Switzerland.*