

Speech Therapy and Assessment (via multimedia devices for Cleft Lip and Palate Patients)

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Abstract- Cleft is a major problem in developing countries where millions of children suffer with Cleft Lip and Palate. Affected children cannot eat or speak properly and are not allowed to attend school or hold a job. Socially they are forced to live an isolated life, filled with shame, pain and heartache. In India, every year 40,000 children are estimated to be born with Cleft. Surgery cosmetically corrects cleft of the child, however post surgery the child needs to undertake Speech Therapy (for improving speech) with a Speech Pathologist. This immensely benefits them and helps them have a normal mainstream life. However in developing countries, there is an acute shortage of Speech Language Pathologists (SLP). Further, patients who are from economically challenged backgrounds (particularly rural areas), cannot afford to travel distances to avail speech therapy frequently at medical institutions, since they and their family members mostly work on daily wages. Our innovation addresses the need for Speech Therapy for Cleft children by leveraging mobile and media technology. This innovation reduces the need for patients to be physically present at the hospital for Speech Therapy and in addition to this; the Speech Pathologist can review the progress of Cleft patients. Basic algorithms have been designed, using Digital Signal Processing and speech signal cross correlation techniques, to compare speech patterns of Cleft patients (against normal person speech). The innovation is patient centric and concentrates on enhancing speech via intuitive sing along games to motivate the child. This will revolutionize the way healthcare services are viewed and will build a level of transparency and accountability for patient care in the ever expanding healthcare domain. Periodically, the patient can remotely communicate with a Speech Therapist using VOIP based video conferencing capabilities whereby SLP can view the facial and tongue movements of the patient and suggest changes in speech therapy drills if required.

Keywords- *Speech Therapy Drills; Speech Language Pathologist; Cleft patient; Cross Correlation Coefficient; J2ME; Mobile Phone.*

I. INTRODUCTION

The rationale is to address the challenge of providing treatment to Clefts patients to enable them to be accepted in the community without feeling neglected.

Rural children with cleft problem not only have the misfortune of dealing with the affliction, but also do not have the means to receive adequate treatment. Even after surgery which cosmetically corrects the lip and palate defects of child, it is necessary that the child undertakes speech therapy from a speech pathologist to benefit fully and to be absorbed in the mainstream. Speech-language therapy is given today by a Speech Language Pathologist (SLP) who works with a patient one-on-one, in a small group, or directly in a classroom.

The problem in developing countries is that there is an acute shortage of Speech Language Pathologist. Further, patients who are from economically challenged backgrounds (particularly rural areas), cannot afford to travel distances to avail speech therapy frequently at medical institutions, since they are predominantly dependent on daily wages.

The good news is that every single child with a cleft can be helped with surgery that costs as little as \$250 that takes as little as 45 minutes.

Post surgery it is imperative that the patient pays periodical visits to the speech pathologist, whose endeavor is to rectify and enhance the patient's speech patterns.

However the following constraints hamper the progress: -

- The patient's family cannot bear the cost of travel
- Traveling to the nearest medical facility is cumbersome
- Patient cannot afford to stay for long for treatment as he/she is on daily wage
- Patient does not see any value addition in taking speech therapy sessions

Tata Consultancy Services is collaborating with Smile Train (not-for-profit, organization) considered for this innovation of using mobile technology to assist Cleft Patients.

II. OBJECTIVE

Tata Consultancy Services (TCS) is building an innovation to bring the Speech Pathologist to the Child by leveraging mobile technology and providing Speech Therapy drills. Also using this innovation the Speech Pathologist can review the progress of the cleft child periodically. This innovation would also give more leverage to Speech Language Pathologist (SLP) to review more patients.

Since the major challenge is that the patient is unwilling to travel to the medical facility for speech therapy, it is important to look at a viable alternative to ensure that the patient receives therapy.

Tata Consultancy Services Limited (TCS) has understood the need to use mobile technology as a key enabler to provide for patient's speech therapy needs within the healthcare domain.

III. METHODOLOGY

TCS has defined two probable ways to address the challenge mentioned in section II: -

1. Mobile Technology to provide basic Speech drills sessions to the patients and be able to collaborate and communicate with a Speech Therapist. This would enable patients to be able to receive Speech Therapy at their convenience, without jeopardizing their daily activities.

2. Extend the innovation to portable multimedia devices or Set-Top-Box for Cleft patients. The main advantage being the patient can view speech therapy drills on a larger screen (e.g TV) and will enable the patient to view facial and tongue movements for specific purpose. Also the patient can communicate with the Speech Therapist using free VOIP based video conferencing capabilities built into the device.

TCS plans to extend its IT services to Smile Train to pursue option 1 as part of a controlled pilot.

To evaluate improvement/change in speech of patient after administering speech drills for a time period, we propose the following process to be carried-out periodically:

TCS intent is to measure similarity between cleft patient's speech (Audio Wave) and normal person's speech (same age group and gender as that of the patient). This is proposed to be done in an innovative way by finding cross correlation coefficient between the two audio waves. As per signal processing concept, higher the cross-correlation coefficient, similar the two waveforms are. This has to be assessed periodically to monitor patient's speech improvement/change. This would enable to seek SLP's guidance in time, if required, for further improvement in patient's speech by suitably suggesting new speech drills on mobile for the patient.

Propose to build computer algorithm based upon the following standard formula for cross correlation coefficient between two signals $x = x_1, y = y_1$ with integer time index 1 .

$$\rho = \frac{\frac{1}{K+1} \sum_t (x_t - \bar{x})(y_t - \bar{y})}{\sqrt{\frac{1}{K+1} \sum_t (x_t - \bar{x})^2 \frac{1}{K+1} \sum_t (y_t - \bar{y})^2}} \quad (1)$$

Where \bar{x} and \bar{y} denotes mean values and summations taken over a segment of length $k+1$ and ρ is Cross Correlation Coefficient.

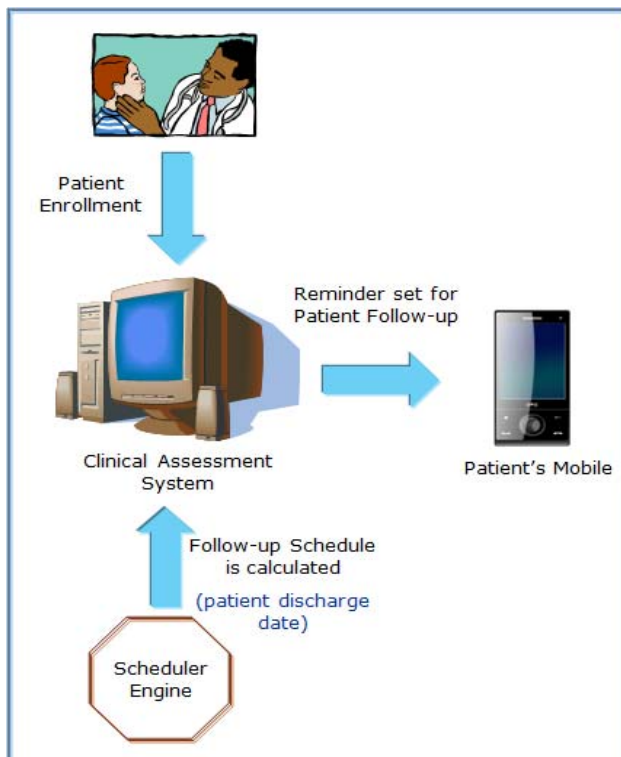
IV. SOLUTION DETAILS

The following are the mobile applications which can be developed by using J2ME capabilities: -

- Reminder Scheduler for Patient Follow-up
- Speech Therapy Drills

Reminder Scheduler for Patient Follow-up

It is important that the patient to know when the next hospital appointment is. Based on the patient's discharge date, the system can automatically calculate the schedule and pass it on to the patient for confirmation.



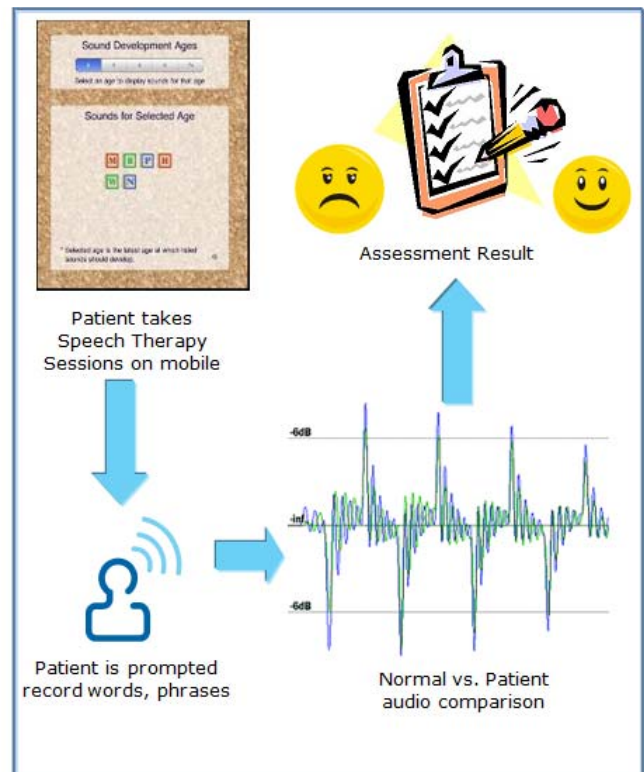
The following are the steps for Reminder Scheduler: -

- Pre-requisite
 1. Application payload will reside on the mobile
 2. Scheduler Engine will be configured for all permutations & combinations of Cleft Lip and Palate (based on age, gender, type of surgery etc ...)
- Patient enrollment is done by the hospital coordinator
- Based on patient discharge date, scheduler engine will create patient follow-up schedule
- Schedule is pushed onto the mobile handset (hardwired)

- Mobile application will alert the patient for follow-up

Speech Therapy Drills

The challenge has always been that the patient primarily cannot visit the hospital frequently. By enabling patients to avail speech therapy sessions on mobile phones, it becomes increasingly beneficial to get the patients' buy-in.



The following are the steps for Speech Therapy Drills: -

- Pre-requisite -
 - Application payload will reside on the mobile
- Patient takes Speech drills pre-loaded on his mobile phone
- Patient is prompted to record words, phrases via a visual interactive interface.
- Mobile Application will compare Patients recorded audio with Normal audio.
- Wave is created with the speech differences.
- Assessment result is shown to Patient (either with success or failure). Child pronunciation is shown as animation (bird in cage or frog in pond) to encourage the child to take similar speech therapy drills.

Challenges:

- Normal sound recordings of the particular age group and gender
- Speaker on low cost mobile device
- Earphone quality on low cost mobile device
- No Visual cues

Benefits

The need for mobilizing healthcare applications and processes is at an all time high. Healthcare Providers, Doctors, Clinicians and Nurses need real-time access to patient, schedule, billing, drug and other practice related information to provide the best patient care.

- Reduces travel for patient to visit hospital/SLP for speech drills
- Saves time and money for poor rural patient by reducing travel and staying expenses
- Patient can perform speech drills using mobile phone at his/her convenient time and place
- Patient is reminded for speech drills by alerts
- Patient is reminded for follow-up visits to SLP
- Real-time access to healthcare business information on smart mobile devices.
- Healthcare providers and partners to have complete access to information while ensuring patient confidentiality.
- The doctors with can manage appointments at their finger tips and take spontaneous decisions.
- The doctors can view the patient scheduling and alter appointments as necessary. This gives them an over view of the work load.
- Reduction of Revenue Leakage, as the doctor can bill the hospital by tracking the patient visit and time spent.
- Alerts for doctors to keep track of appointments and rescheduling can be done based on the criticality of the patient visit.
- Doctors to trigger new prescription and prescription refills.
- Mobilization of critical business applications, forms & reports irrespective of the technology, data location, and mobile device type.

By Mobilizing Patient Management System, the healthcare Management can be taken to the next level by enabling:

- Instant communication between doctors, nurses and other healthcare professionals.
- Real-time access to Electronic Health Records (EHR) and Electronic Medical Records (EMR).
- Real-time access to scheduling, billing, and drug information.
- Mobilization of primary and acute care applications by integrating nurse calls, critical alerts, vital sign monitoring, etc.
- Streamlining of ER processes.
- Streamlining of home-based medical care by enabling two-way communications between the caregivers and healthcare administrative systems.
- Secure transmission of patient data ensuring confidentiality (HIPAA).
- Real-time access to insurance and claims information.
- Enhancing speech therapy of patients by providing courses on the mobile.

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