Rhema Project Overview

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Sarver and Associates, Inc.
1022 Briarcrest Lane
Cookeville, TN 38501

Tel.: 931-432-0369

Mobile: 931-239-5560

www.saavision.com

Executive Summary

Rhema is the Greek word for *utterance*, which is synonymous with the spoken word. The Rhema project was established to develop a computer and/or cloud based system to assist in the treatment of speech pathologies, with the goal of exploiting the application of new technologies, and the integration of customized hardware and software, for the development of improved therapies for communication disorders and/or communication variations, with special emphasis on the treatment of articulation disorders, phenology, morphology, and accent/dialect modification.

The objectives of the Rhema Project include the following:

1. Monitoring a subject via real-time video (viseme) and audio (phoneme) to capture a high-level representation of what is being communicated. This includes identification of specific facial landmarks and speech recognition.
2. Facial landmarks will be used to analyze how the speaker is attempting to make certain sounds and to provide visual feedback on how these landmarks are expected to be positioned.
3. Audio will be analyzed for proper sounds and waveform graphs will be generated to help point out where differences between expected and actual sounds are detected.
4. Through the collection of data during clinical trials, we will create corrective therapies tailored to the individual subject. Algorithms will compare captured speech to the targeted phenology speech database (e.g., American English) and corresponding determination of normal population facial posture and movement of jaw, lip, and tongue position with facial landmarks.
5. Provide subjects with immediate feedback to substantially improve their ability to form words and speak clearly
6. Record video and audio for the speaker while providing quantitative and qualitative graphical feedback on their performance
7. Provide data storage and communications

A top-level architecture for Rhema showing major components is depicted in Figure 1.

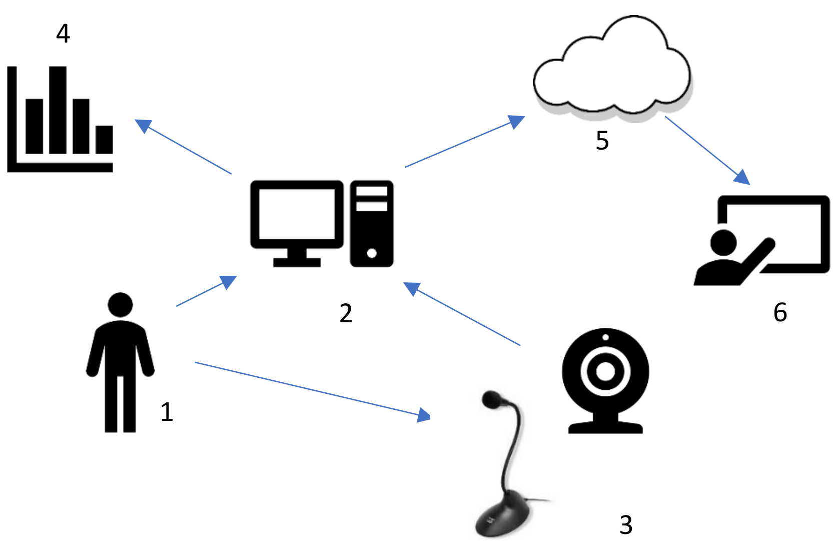

Figure 1. Rhema System Architecture.

In Figure 1, hardware and software integration with the subject/user depicts the architecture of the Rhema System. The subject (1) interacts with a computer running Rhema programs (2), camera and microphone (3) record the subject, captured audio and video analysis is performed by Rhema programs (2), and generated output (4) provides feedback loop and correction. Results from each session are saved to track subject progress (5), which can be shared with others (6) for real-time consultations with specialists, assist in development of tailored treatment therapies, and/or used as advanced classroom aids for the training of speech pathology diagnosis and treatment methods.

Following initial setup and calibration procedures, the subject begins interacting with the Rhema System (analysis and therapy modules). The calibration process begins by capturing front and side views of the user's face and acquiring a targeted audio sample. Captured views of the subject's face are analyzed to determine facial landmark registration and produce an output texture, which is used in generating a custom virtual reality rendering of the user. Captured audio samples are utilized for comparison with the subject's select language phenome database, and to produce a baseline frequency model of the user's voice, which will also be used to shape the tone of synthesized speech to better match the user for corrected speech output examples. State-of-the-art algorithms will be developed and/or utilized for the mapping of key facial landmarks, enabling the detection and tracking of eyes, nose and mouth (lip/jaw) movement, facial gesturing, and implied tongue positioning. See Figure 2 below.

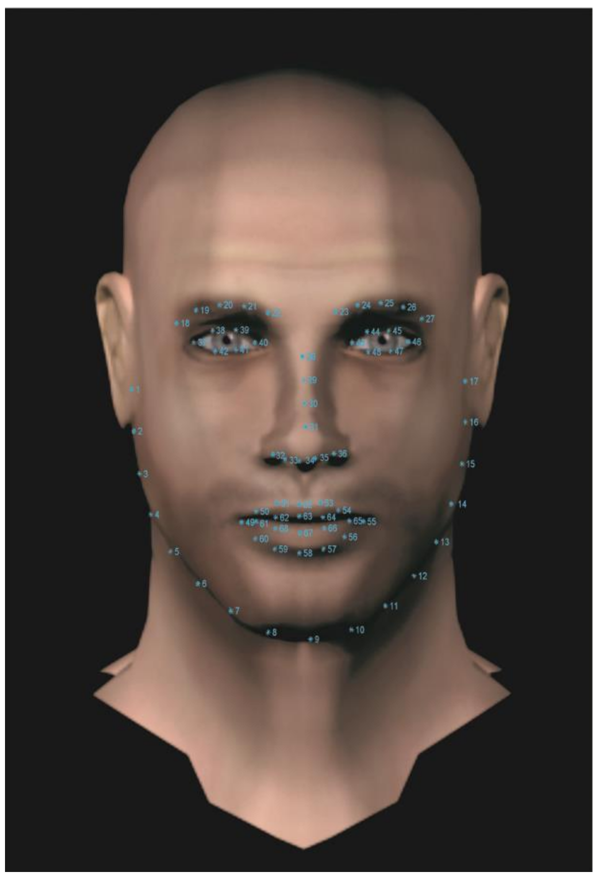

Figure 2. Rhema will utilize front and side views of the subject, calibrated to facial landmark registration, and combined with audio samples to establish the subject baseline.

During therapy, an animation of the user is synchronized with a synthesized audio sample, which is presented to the user to repeat, with optional text and phonetic captions. Using real-time facial tracking algorithms, the user will see an image of their face on one side of the screen and the artificial image with the correct mouth orientation on the other. With semi-transparent overlay techniques, the user can be shown and prompted for correct facial posture - tongue position, and movement.

As the user repeats the targeted phrase or therapy exercise, analysis indicates the difference between the user's actual facial position, movement, and implied tongue position, with that of the expected position and movement. Highlighted areas of both the video and audio waveform will provide feedback to identify specific areas of error for correction. See Figure 3 below.

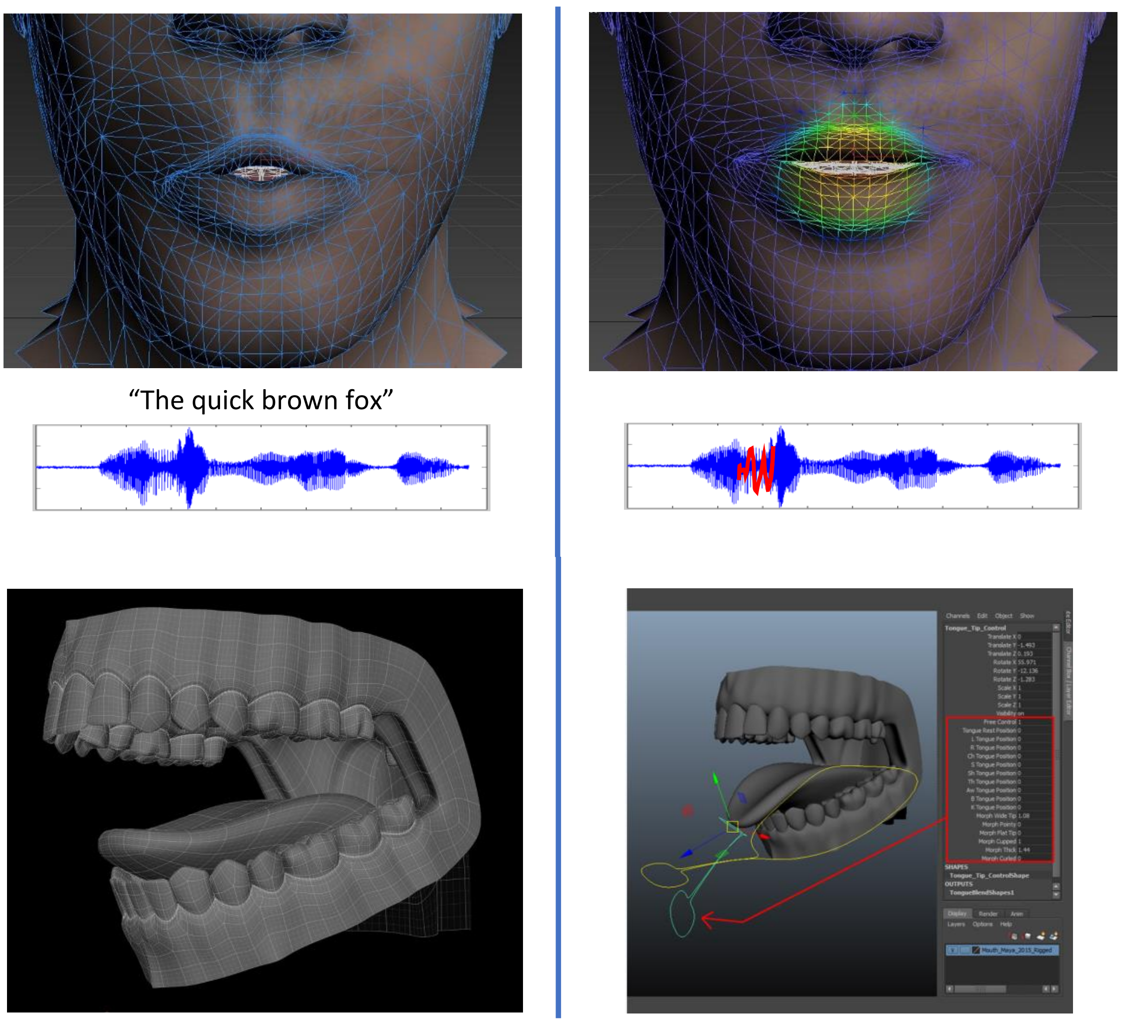

Figure 3. Subject correct facial position, audio waveform, and jaw/tongue position/movement are depicted above on the left side of the figure. Error regions are depicted above on the right side of the figure, with highlighted areas providing a feedback loop for subject correction.

A status display is also provided to the subject, generating both a quantitative and qualitative performance assessment of each therapy exercise, and the overall session. A more detailed display is generated for the therapist or clinician who is working with the subject, providing detailed performance metrics, user video and audio recordings, and tracked case progression over time. The therapist or clinician will be able to send additional tailored treatment therapies to the subject, based on their progress.

Rhema Treatment sessions

The treatment provider can utilize the network for further analysis, update treatment plans, and optimize treatment sessions. The Rhema system could be utilized in a centralized treatment facility, satellite facilities, or even remotely, such as in the subject's home or school.

The user will be able to work at their own pace at a time that is convenient for them.

Rhema Application Areas

Potential application areas for Rhema are: (1) Speech variation correction for the hearing impaired. (2) Speech articulation disorders and treatment therapies. (3) Classroom aid and/or learning tool for the training of speech pathology diagnosis and treatment methodologies. (4) Accent/dialect modification.

Research and Funding Adjacencies

How can the Rhema Project best leverage ongoing NIH research efforts, available grants, and/or open funding opportunities for expedited prototype development, testing, and fielding?

How can Rhema Project objectives and concepts influence and better align with future SBIR/STTR research topics and scope?

About Sarver & Associates, Inc.

Sarver & Associates, Inc. (SAA), founded in 1995, is a small, woman-owned, privately held company that provides consulting services in the areas of software development, image processing, optical analysis, as well as design and development of ophthalmic and biometric systems. In addition to Rhema Project research into improved speech pathology tools/therapies for articulation disorders and correction of articulation variations (accent/dialect modification), SAA develops analysis and display software for commercial and research clinical ophthalmic systems such as corneal topographers (measures the cornea), ocular aberrometers (measures the eye's aberrations), optical coherence tomographers (measures surfaces from the cornea to the retina), as well as anterior and fundus imaging systems. SAA also designs advanced intraocular lenses (IOLs) for implantation into eyes to correct vision with or without the natural crystalline lens in place. SAA also provides analysis for IOL power calculations for use in preoperative planning, intraoperative IOL selection, and postoperative IOL refractive surprises. SAA has developed biometric systems using the eye and is currently working on automated coin surface processing and automated video translation. SAA has participated in several SBIR and R01 research grants.

The Rhema Project Leadership Team:

Charlene Sarver
casarver@saavision.com

Mrs. Sarver is the Chief Executive Officer and President of SAA, which she co-founded after a successful career with the National Aeronautics and Space Administration (NASA). Previously, she was the Deputy Division Chief of Safety Operations at the Kennedy Space Center. Mrs. Sarver has extensive engineering, operations, and project leadership experience involving management of cutting-edge technologies. Her education includes BS degrees in Thermal and Environmental Engineering, and Chemical Engineering.

Ed Sarver, PhD
ejsarver@saavision.com

Dr. Sarver is the Chief Technology Officer, Vice President, and Co-Founder of SAA. Previously, he was Vice President of Research and Development for EyeSys Technologies, Inc., and has been a consultant in the medical and biometric device industries for over 25 years, providing subject matter expertise in the areas of image processing, optical analysis, and the design and development of ophthalmic imaging systems. Dr. Sarver has been the principal investigator or consultant on numerous SBIR/R01 grants; he has over 20 patents; has authored more than 20 peer-reviewed journal articles and a book chapter; and has held past engineering roles with the Harris Corporation and Texas Instruments. Dr. Sarver has been an invited speaker and presented papers at numerous ophthalmic conferences, and reviews manuscripts for several major ophthalmic journals. His education includes a PhD in Electrical Engineering.

Max Hall
mhall@saavision.com

Mr. Hall is a software development consultant, entrepreneur, and US Patent Holder, who has been a recognized leading force in several high-tech. start-up companies, providing both technology leadership and design architecture acumen to numerous, innovative, leading-edge product developments. He has over twenty years' experience in the development of real-time application and embedded software and hardware for military, industrial, and medical systems. Mr. Hall has authored or coauthored numerous publications, and is a recognized expert in complex analysis involving numerical, optical and image analysis and display, Matlab; software engineering involving critical, medical software development for intraoperative aberrometry; and real-time hardware status/control and graphics. His education includes computer science studies at the American College of Computer & Information Sciences.

Jack Blood
jblood@saavision.com

Mr. Blood is a business management executive with extensive experience successfully managing highly-complex engineering, advanced technology programs and operations, involving significant profit and loss responsibility, strategy, and business development for Fortune 100 Companies such as Lockheed Martin, General Dynamics, and Northrop Grumman. Mr Blood was a past management consultant to the Senior Executive Service (SES), Assistant Director of Aviation and Missile Systems – Army Aviation and Missile Research, Development, Engineering Center (AMRDEC), Redstone Arsenal, and is also a veteran of military service (former officer and aviator). He is a Lean Six Sigma practitioner certified through Purdue University, and has completed the Villanova University Project Management Certification Program. His executive education includes the MBA Certificate Program with Tulane University's A. B. Freeman School of Business, and the American Management Association (AMA) Corporate Leadership Development Program. He holds a BS degree from Excelsior College, and an AS degree from Central Texas College.