AWARD NUMBER: W81XWH-17-C-0238

TITLE: Complete and Resilient Documentation (CARD) for Operational Medical Environments

PRINCIPAL INVESTIGATOR: Kuang-Ching Wang, PhD

CONTRACTING ORGANIZATION: Clemson University
Clemson, SC 29634

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14. ABSTRACT

In response to the HITI HFEHRI solicitation for research to demonstrate and validate hands-free electronic health record data entry solutions that will operate reliably in noisy operational environments, alleviate disruption of care for documentation, and prevent loss of documentation, this project studies a system-oriented approach to meet these objectives with a platform aimed to enable resilient hands-free data collection, preserve complete documentation through stages of care, and present timely information useful for the medical operation.

15. SUBJECT TERMS

Battlefield, Hands-free, Electronic health record, Documentation, Operational environments, Medical Workflow, Stages of care, Speech recognition, Noise, GPU, Deep learning, Neural network, Video, Simulation

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1. INTRODUCTION:

In response to the HFEHRI (Hands-Free Electronic Health Record Data Entry Initiative) solicitation for research to demonstrate and validate hands-free electronic health record data entry solutions that will operate reliably in noisy operational environments, alleviate disruption of care for documentation, and prevent loss of documentation, this project studies a system-oriented approach to meet these objectives with a platform aimed to enable resilient hands-free data collection, preserve complete documentation through stages of care, and present timely information useful for the medical operation.

2. KEYWORDS:

Battlefield
Hands-free
Electronic health record
Documentation
Operational environments
Medical
Workflow
Stages of care
Speech recognition
Noise
GPU – Graphics processing unit
Deep learning
Neural network
Video
Simulation

3. ACCOMPLISHMENTS:

What were the major goals and objectives of the project?

Specific Aim 1 – Medical Workflow Studies

Task 1.1: Focus Group/Interviews

Focus groups/interview design (months 1-3) – 100% Completed on 12/1/17
Local IRB Approval (month 3) – 100% Completed on 11/17/17
Focus Group recruitment (month 4) – 100% Completed on 1/31/18
Focus groups/interviews meet (month 5) – 100% Completed on 2/6/18
Transcription, analysis and operation recommendation of focus groups (month 6) – 100% Completed

Task 1.2: First EMS Drill

Drill #1 design and preparation (months 1-2) – 100% Completed on 11/1/17
Drill #1 execution (month 3) – 100% Completed on 11/17/17

Post-drill transcription and data to software team (months 4-6) – 100% Completed on 12/11/17

Task 1.3: Qualitative Assessment

Quality assessment instrument design (months 7-12) – 80% Completed -This task will define quality goals and instrument needed to assess the medical effectiveness of CARD. To date, we have decided to base the design on the DD 1380 TCCC card. Remaining work focuses on determination of information priority and CARD integration requirements.

Specific Aim 2 – Platform Development

Task 2.1: Platform Integration

Acquisition of components (months 1-3) – 100% Completed
Platform and data interface integration (months 4-6) –100% Completed
Cerner interface validation (months 1-6) –100% Completed
Speech and video software integration (months 7-12) – 100% Completed

Task 2.2 – Speech Recognition & Video Digest

Speech Recognition development (months 1-6) –100% Completed
Data preparation & training (months 4-9) – 100% Completed
Video digest (months 10-15) – 40% Completed
Cerner integration (months 10-15) –40% Completed

Specific Aim 3 – Assessment

Task 3.1: Technology Assessment

Platform benchmarking (months 10-12) – 60% Completed. Assessment plan is extended into Q5 due to new speech recognition design to address performance challenges due to battlefield noise.
Drill #2 design and preparation (months 10-15) – 40% Completed. In response to new assessment plan (Tasks 1.3, 3.1), drill #2 is re-positioned as a developmental drill to acquire recordings of medical dialogues consistent with the assessment standard. An additional drill (drill #3) is planned beyond drill #2 for full assessment.

a. **What was accomplished under these goals?**

The project to date has had the following major activities and findings. With respect to each specific aim:

1. Medical Workflow:
    a. **Completed drill #1 with video and audio recordings (with transcription) to be used by Clemson engineers in the development of the hands-free capture system. (Appendix A).**

    Drill description and outcomes: The drill was conducted at the Palmetto Health Simulation Center in Columbia, SC on 17 November 2017. The facility is regularly used for training medical and nursing school students on a broad range of medical treatments. Our drill was carried out closely following the protocol detailed in our proposal, with professional actors acting as patients afflicted with three different injury types (below knee amputation with arterial bleeding

secondary to an improvised explosive device injury, gunshot wound through chest with respiration distress, and blast injury with concussion (altered mental status) and tympanic membrane perforations). Within the Simulation Center we had three simulated operational platforms (battlefield, air transport and military field hospital scenes).

The first was a battlefield scenario with camouflage and other props which simulated a combat scenario. Battlefield sounds were added for a sense of realism. Battlefield sounds were thoughtfully prepared (various weapon sounds) with the noise volume controlled and varied with each "casualty run". Simulated injured soldiers were initially assessed (following a written script) by volunteers of the Richland County Emergency Medical Services employees. When assessment and initial care was provided (per protocol), the injured soldier was moved to a second scenario which represented helicopter transport. This scenario was staffed by two helicopter transport nurses (affiliated with Palmetto Health) who provided en-route care to the soldier while in transport to the simulated field hospital. Here too realistic helicopter noise was transmitted into the environment with the volume adjusted by casualty run. The staff followed scripts and completed their role in the care continuum. The last scenario was a simulated field hospital populated by two emergency physicians (one holding an Army reservist appointment) of Palmetto Health. In this final scenario the physicians followed their script in emergency care for the soldier.

Two medical personnel and a patient were present in each scenario, and their conversations were videotaped, and audio recorded by six GoPro cameras (one on each medic). A total of eight simulation runs (1.2 hours worth of recorded action) were recorded. In addition, the Simulation Center recorded video copy of each casualty run from fixed cameras. A copy of the Simulation Center video content was delivered to Clemson researchers.

All data collected were recorded and transcribed by a third party. Both audio and video recordings were transcribed into Word documents. This data was given to the CARD technology development team.

b. Completed focused group sessions with EMS personnel, helicopter transport nurses, and emergency physicians with the goal of identifyng key requirements, expectations, related to this hands-free communication system (Appendix B).

FINDINGS: The full findings were presented at MHSRS 2018 (Sarah Griffin, et al., oral presentation in Mobile Health Applications in the Medical Theater of Operation session). Six focus group interviewed EMS personnel, flight nurses, and Emergency Department physicians, some with prior military medical experiences. Focus group discussions followed a medical workflow process beginning prior to treating a patient through transferring the patient to the next level of care. During each phase participants were asked questions about communication, information collection, information documentation, environmental assessment, and challenges/strength of video and audio recording during that phase of care. All data collected was recorded and transcribed. Focus groups were recorded, transcribed and analyzed in Atlas ti using a grounded theory approach to identify themes and develop thematic networks. Dr. Griffin and Dr. Gimbel began analysis using an inductive (open coding) process. From this process a set

of codes were identified and applied to the transcripts. The next analysis phase examined interrelationships within and between codes and code groups (axial coding). Thematic areas constructed from the analysis include: workflow communication, information use, information transmission, and device logistics. A formal report with recommendations will be generated to advise the CARD technology team and copy delivered to USAMRMC; we anticipate crafting a scientific manuscript on the outcome as well.

Focus Group Results (Key issues): Four primary themes were identified: Communication during workflow, information use, information transmission and device logistics. Each theme had multiple subthemes. Specific recommendations relevant to engineering requirements include:

- Medics tend to communicate differently in different phases, sometimes subtle and not verbal when in tactical situations or when they have a history of working together;
- Medics often need to care for multiple patients in parallel (caring for one and talking to another) which could confound the proposed system; need to compensate for this;
- From the emergency physician perspective, notes presented to them need to be brief (void of unnecessary information) and follow a template;
- Emergency physicians are willing to watch a short 10 second video (presented with the note) if relevant to injury;
- Ideally, the note and image would be transmitted to the emergency physicians/staff while the patient is still in transport prior to arrival;
- Wireless transmission of electronic data could negatively affect military operations regarding signal location of casualty location;
- Medics prefer a manual ability to turn recording device on and off; and
- Locating the camera on glasses or helmets might make sense.

2. Platform activities:
    a. We purchased ~500 hours of speech data from the Linguistic Data Consortium (UPenn) for training speech recognition algorithms;
    b. We fully acquired and integrated the video/audio capture from drill #1 into the real-time processing platform;
    c. Our speech recognition solution has been implemented; extensive testing and multiple enhancements are underway;
    d. The video digest feature has been integrated into the platform, with advanced features planned for Y2; and
    e. Our approach and limitation for Cerner integration has been verified; we are actively engaged with Cerner on FHIR gaps and the road map for operational medicine support.
3. Assessment:
    a. We completed a technology assessment of multiple open source speech recognition software programs for potential use with various noise conditions (Appendix C).
    b. We began work on assessment instrument based on DoD TCCC card – For speech recognition performance, we began developing metrics that reflect the percentage of information that can be acquired through the CARD software. For medical workflow performance, we plan to build post-operation surveys for the personnel participating in the drills (Appendix C)

What opportunities for training and professional development has the project provided?

Nothing to report.

How were the results disseminated to communities of interest?

Results to date have been presented at the 2017 and 2018 Military Health System Research Symposiums:

1. Sarah Griffin, K.C. Wang, Ron Gimbel, William Gerard, Steve Shelton, Kelly Hawsey, "Complete and Resilient Documentation (CARD) of Operational Medical Environments – Knowledge and Insight from Focus Groups Regarding the use of GoPro® equipment in Military and Civilian Medical Environments," Oral Presentation, Military Health System Research Symposium, Aug. 2018. (Appendix B)
2. K.C. Wang, Ron Gimbel, Melissa Smith, Marcin Ziolkowski, William Jennings, William Gerald, Steve Shelton, "Complete and Resilient Documentation (CARD) for Operational Medical Environments," Poster Presentation, Military Health System Research Symposium, Aug. 2017. (Appendix D)

What do you plan to do during the next reporting period to accomplish the goals?

Specific Aim 1 – Medical Workflow Studies

Task 1.3: Qualitative Assessment

Quality assessment instrument design (months 7-12) – Completion of design of assessment instrument and assessment procedure in Q5.

Survey Execution and analysis (months 13-18) – Conduct drill #2 as additional development drill with preliminary survey.

Specific Aim 2 – Platform Development

Task 2.2 – Speech Recognition & Video Digest

Video digest (months 10-15) – In addition to the already completed basic video digest function linking video footage based on timestamp of recognized speech, in Q5, we will explore additional, more challenging video analysis such as facial identification of known persons.

Cerner integration (months 10-15) - After contacting Cerner FHIR, it was confirmed that Cerner FIHR does not support the interface for external software to upload data into the patient record. We will continue to work with Cerner to identify road map for integration and set up a local server to display data records from the proposed project work.

Specific Aim 3 – Assessment

Task 3.1: Technology Assessment

Platform benchmarking (months 10-12) – Platform benchmarking will continue into Q5 with new metrics and assessment methods.

Drill #2 design and preparation (months 10-15) – Will plan and execute Drill #2 in December 2018.

Drill #2 execution (month 18) – Based on new plan, drill #2 will be for developmental purpose and may take place earlier than month 18. In addition, drill #3 will be planned for full assessment.

Specific Aim 4 – Roadmap Development

Platform usability and gap assessment (months 19-24)

4. **IMPACT:**

What was the impact on the development of the principal discipline(s) of the project?

Impact on state-of-the-art understanding of speech recognition technology challenges for battlefield environment:

- Deep look into the question "is state-of-the-art speech solutions, either academic or commercial, ready for the balltlefield?"
    - Produced systematic benchmarking of two most advanced open source neural network-based speech recognition software by Mozilla (DeepSpeech) and John Hopkins University (Kaldi) with respect to battlefield noise of different types and intensity and concluded severe performance degradation with battlefield noise.
- Build foundations for DoD's long-term success in speech recognition competencies:
    - Produced systematic assessment and analysis of speech recognition correctness's dependencies on algorithms, processing, and data (training).
    - Derived approach to systematic assess specific speech recognition enhancement actions with measurable performance impacts

What was the impact on other disciplines?

Nothing to Report

What was the impact on technology transfer?

Nothing to Report

What was the impact on society beyond science and technology?

Nothing to Report

5. **CHANGES/PROBLEMS:**

Changes in approach and reasons for change

We have made a modest change to our planned drills based on findings from speech recognition deveopment and testing since drill #1. The increased understanding of the root cause of the degradation caused by battlefield noise led to a need for enhancement solutions not in place today. The adjusted plan will increase with one more "developmental drill" to collect data needed to develop and validate an approach that will enable persistent, incremental enhancement of speech recognition performance, specific to military medical language and noise conditions, towards a robust speech solution for DoD battlefield operations.

Actual or anticipated problems or delays and actions or plans to resolve them

The challenges seen in speech recognition software have already extended the needed testing and development time to: 1) produce a systematic deep-look study of the noise impacts and

resolutions, and 2) plan for an additional drill study to incorporate specific medical terms. While this delayed the original intended schedule, we believe this is a required step that will give us valuable guidance to the needed steps towards a robust technology development plan. We will continue to monitor the progress of findings and report accordingly.

Changes that had a significant impact on expenditures

Due to delays in hiring a graduate student with a much-desired expertise in speech recognition, as well as a similar challenge in identifying a post-doc with a fitting expertise, we have delayed spending in salary line. The graduate student started in August 2018 and immediately made significant contributions. In addition, since June 2018, we remedied the situation by hiring a post-doctoral researcher on a part time basis (due to her limited available time) to the project team leading to scientific publication efforts.

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents:

Significant changes in use or care of human subjects
Nothing to Report

Significant changes in use or care of vertebrate animals
Nothing to Report

Significant changes in use of biohazards and/or select agents
Nothing to Report

6.PRODUCTS:

Publications, conference papers, and presentations

US Army News: https://www.armytimes.com/news/2017/12/18/device-would-help-combat-medics-document-treatment-in-the-field/

Post and Courier: https://www.postandcourier.com/features/clemson-researchers-envision-an-improved-way-to-document-battlefield-injuries/article_24464cf6-dec6-11e7-b159-4f4c3a15847e.html

Clemson World: https://clemson.world/witnesstowar/

Clemson News: http://newsstand.clemson.edu/mediarelations/injured-troops-could-receive-better-care-and-benefits-with-new-research/

Journal publications
Nothing to Report

Books or other non-periodical, one-time publications
Nothing to Report

Other publications, conference papers, and presentations
Nothing to Report

Website(s) or other Internet site(s)
Nothing to Report

Technologies or techniques
Nothing to Report

Inventions, patent applications, and/or licenses
Nothing to Report

Other Products
Nothing to Report

7.PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one-person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate "no change."

Name:	*Kuang-Ching Wang*
Project Role:	*Principal Investigator*
Research Identifier:	*0000-0002-5675-7104*
Nearest person month worked:	*2.25*
Contribution to Project:	*Dr. Wang is responsible for all aspects of the research study.*

Name:	*Ronald Gimbel*
Project Role:	*Co-PI*
Research Identifier:	*0000-0001-8185-4013*
Nearest person month worked:	*1.0*
Contribution to Project:	*Dr. Gimbel supports Dr. Wang and Dr. Griffin in qualitative research, co-coordinating drill #1, and communication with the Palmetto Health Emergency Medicine team.*

Name:	*Sarah Griffin*
Project Role:	*Investigator*
Research Identifier:	*0000-0003-4820-3985*
Nearest person month worked:	*1.0*
Contribution to Project:	*Dr. Griffin will lead focus groups and interviews to glean insight on operational medical workflow.*

Name:	*Melissa Smith*
Project Role:	*Investigator*
Research Identifier:	*0000-0003-0798-8536*
Nearest person month worked:	*1.0*
Contribution to Project:	*Dr. Smith and her graduate students will lead technology enablement activities.*

Name:	*Ashwin Srinath*
Project Role:	*Investigator*
Research Identifier:	*0000-0003-4341-9840*
Nearest person month worked:	*1.0*
Contribution to Project:	*Dr. Srinath will oversee integration of the CPU/GPU platforms.*

Name:	*MinJae Woo*
Project Role:	*Graduate Student*
Nearest person month worked:	*12*
Contribution to Project:	*Mr. Woo supports Drs. Gimbel and Griffin in activities related to the proposed qualitative research, statistical analysis and outcome analysis, and issues related to the drills and workflow. The student will also develop the basic model that controls simulation of battlefield noise.*

Name:	*Caleb Linduff*
Project Role:	*Graduate Student*
Nearest person month worked:	*12*
Contribution to Project:	*Mr. Linduff will focus on platform integration and support Dr. Wang in the area of how to integrate the data into the Cerner electronic health record.*

Name:	*Sufeng Niu*
Project Role:	*Graduate Student*
Nearest person month worked:	*12*
Contribution to Project:	*Mr. Niu will support Dr. Smith's work on speech recognition.*

Name:	*Prabodh Kumar Mishra*
Project Role:	*Graduate Student*
Nearest person month worked:	*3.5*
Contribution to Project:	*Mr. Mishra will focus on assessment for speech recognition.*

Name:	*Yuzhe Yang*
Project Role:	*Graduate Student*
Nearest person month worked:	*3.0*
Contribution to Project:	*Ms. Yang will focus on experiment design and publication.*

Name:	*Snigdhaswin Kar*
Project Role:	*Graduate Student*
Nearest person month worked:	*3.6*
Contribution to Project:	*Ms. Kar will focus on noise generation.*

Name:	*Karen Edwards*
Project Role:	*Research Associate*
Research Identifier:	*0000-0003-3584-0328*
Nearest person month worked:	*1.2*
Contribution to Project:	*Mrs. Edwards assisted with regulatory/IRB approvals from Palmetto Health and Clemson University as well as the approval from the HRPO military secondary review board. She will assist with various reports and logistical items.*

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Nothing to Report

What other organizations were involved as partners?

Organization Name: Palmetto Health System
Location of Organization: Columbia, South Carolina
Partner's contribution to the project:
Financial support: n/a
In-kind support: n/a
Facilities: P*roject staff use the partner's facilities for project activities.*
Collaboration: *Partner's staff work with project staff on the project*
Personnel exchanges: *Project staff and/or partner's staff use each other's facilities, work at each other's site.*
Other: n/a

8.SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS: n/a
QUAD CHARTS: Appendix E

9. APPENDICES:

APPENDIX A - Simulation Drill #1 Photographs

Photo #1: Patient with amputation in battlefield environment

Description: One medic assesses injury while another converses with patient.

BKA with arterial bleeding secondary to IED. This image depicts a patient in the battlefield being treated by one medic and verbally assessed by a second medic. After asking the patient several questions about his medical history, medics verbalizes out loud the MARCH assessment. In this scenario, medics later move the patient onto a helicopter and turnover report to the helicopter crew (with helicopter noises in the background). The helicopter crew examines patient on a stretcher and obtains vital sings. Their findings are reported out loud. The patient is later transported on a stretcher to the field hospital where background noise could include voices, monitors, alarms, etc. From there, the helicopter staff gives their report to the hospital physician who will initiate treatment.

Photo #2: Patient with gunshot wound in helicopter environment

Description: Conversation taking place amidst loud helicopter noise.

GSW through chest with respiratory distress. Scene begins on the battlefield with ambient gunfire and environmental sounds. The medics approach the casualty and begin their initial assessment. The medic then verbalizes the MARCH assessment. Next, the medics move the patient to the helicopter and provide the turnover report to the helicopter crew (with helicopter noises present in the background). Once secure, the flight crew places the patient on a stretcher and obtains vital signs and begins an IV to help with the pain. The flight crew also verbalizes their assessment of the patient out loud—as well as noting any treatment they give the patient. Later, the flight crew transfers the patient to the field hospital where background noises may include voices, monitors, alarms, etc. The helicopter crew states their report to the hospital physician who begins treatment.

Photo #3: Patient with concussion in field hospital

Description: Patient treated in field hospital surgical room.

Blast injury with concussion/TM perf. Scene begins on the battlefield with ambient gunfire and environmental sounds. The medic approaches the casualty and begins assessment. After receiving the necessary information from the patient (allergies, current medications, medical history, etc.), the medic verbalizes the MARCH assessment and then proceeds to move patient to collection point. The medic relays the report to the flight crew who then begin their own assessment on the patient who has continued bleeding from the left ear. The flight crew then verbalizes their assessment—including vital signs—out loud. The flight crew later transports the patient on a stretcher to the field hospital where they relay their assessment to the hospital physician. The physician suspects possible brain injury and begins treatment.

CLEMSON UNIVERSITY

Complete and Resilient Documentation of Operational Medical Environments

Knowledge and Insight from Focus Groups Regarding the use of GoPro equipment in Military and Civilian Medical Environments

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DISCLAIMER

- This material is based upon work supported by the U.S. Army Medical Research Acquisition Activity under Contract No. W81XWH-17-C-0238. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the U.S. Army Medical Research Acquisition Activity.

Project Information

- Organization: Clemson University
- Principal Investigator: Kuang-Ching Wang, PhD
  - Key Sub-Awards: Bill Gerard, MD (Palmetto Health System)
- Period of Performance: 9/25/17-12/24/19
- Grants / Contract Officer Representative: Dr. Prem Yadav
- Grants / Contract Specialist: Jeanette Wolfe
- Related government funding: n/a

Presentation Co-Authors

Sarah Griffin, PhD[1], Kuang-Ching Wang, PhD[1], Ronald Gimbel, PhD[2], Karen Edwards, MS[1], William Gerard, M.D.[3], Stephen Shelton, M.D.[4], Kelly Hawsey, R.N.[4]

- [1]Department of Public Health Sciences, Clemson University
- [2]Electrical and Computer Engineering, Clemson University
- [3]Department of Emergency Medicine, Palmetto Health System
- [4]Palmetto Health System

Presentation Outline

Provide a brief overview of larger CARD study

Describe phase one qualitative research

Research Design / Methods

The CARD Project

Phase 1 Qualitative Research

- Workflow
  - Requirements and operational conditions from physicians and nurses
  - Medical rescue standards and deviations in various operational environments

Data Collection Methods

- Simulation Center Drill Observation
  - 3 injury types
  - 3 settings
  - Observation and informal post simulation interviews
- Six Focus Groups
  - Emergency Medical Systems Responders
  - Transport/Flight nurses
  - Emergency Department Physicians

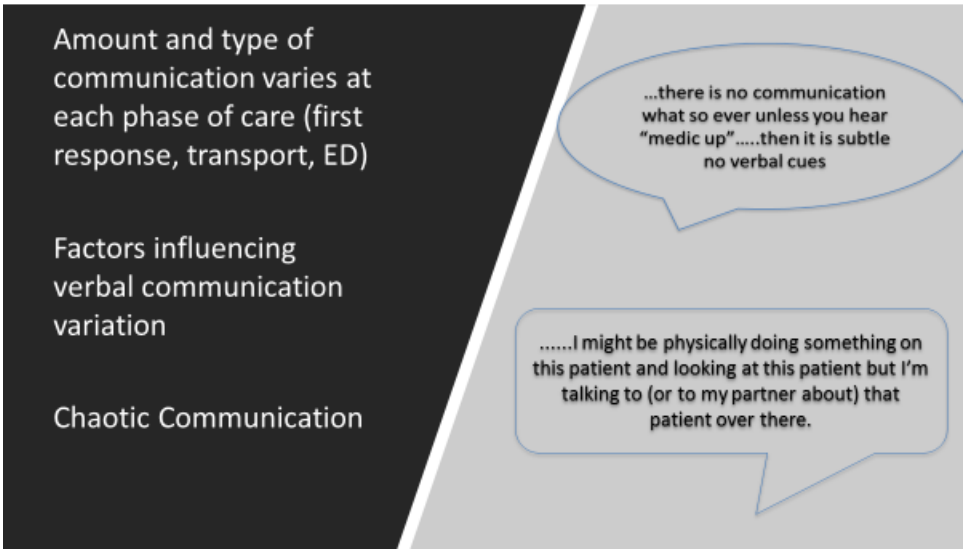
Focus Group Participants

	Total n	Male n (%)	Female n (%)		Experience <10 years n (%)	Experience 10-20 years n (%)	Experience >20 years n (%)	Experience Unknown N (%)
EMS	6	5(83%)	1 (17%)		1 (17%)	1 (17%)	3 (50%)	1 (17%)
Transport Nurses	11	8 (73%)	3 (27%)		1 (9%)	2 (18%)	8(73%)	0 (0%)
ED Physicians	9	8 (89%)	1 (11%)		3 (33%)	2 (22%)	4 (44%)	0 (0%)
Total	26	21(81%)	5 (19%)		5 (19%)	5 (19%)	15 (58%)	1 (4%)

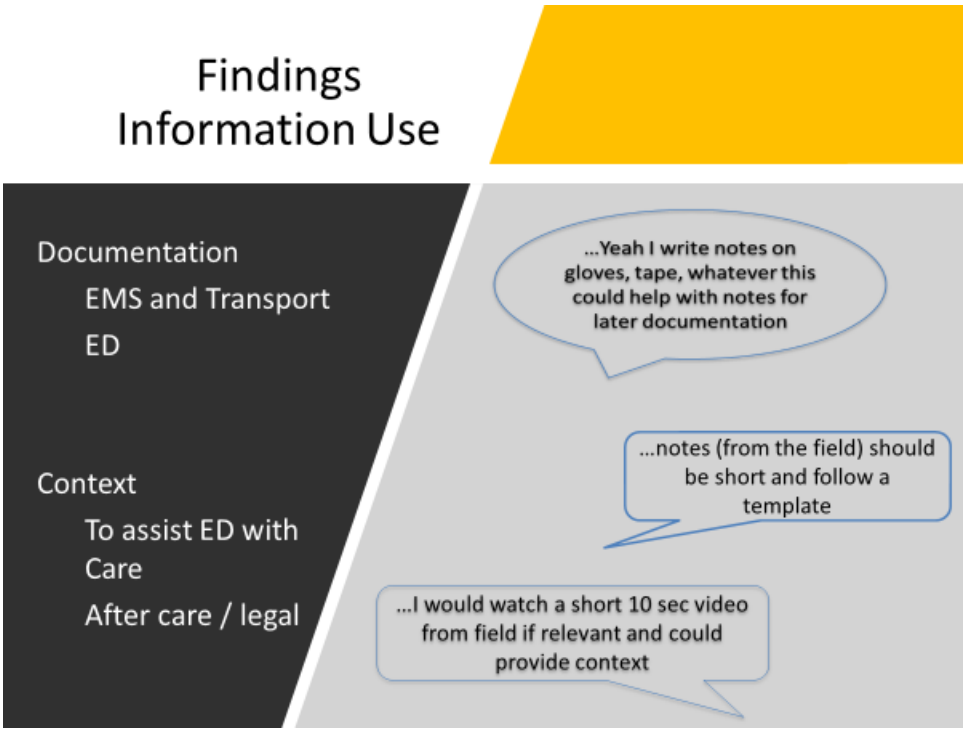
Findings
Thematic Areas

- Workflow Communication Variations
- Information Use
- Information Transmission
- Device Logistics

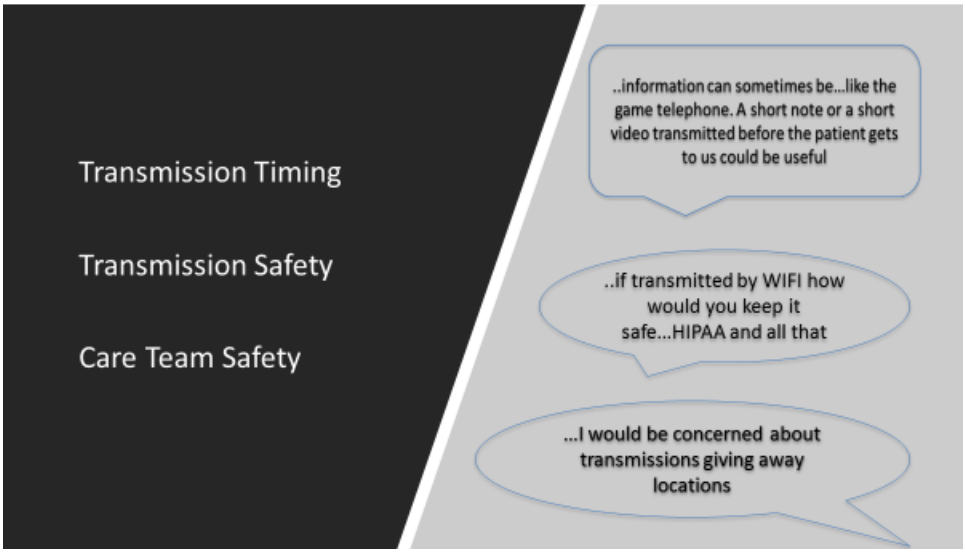
Findings
Workflow Communication Variations



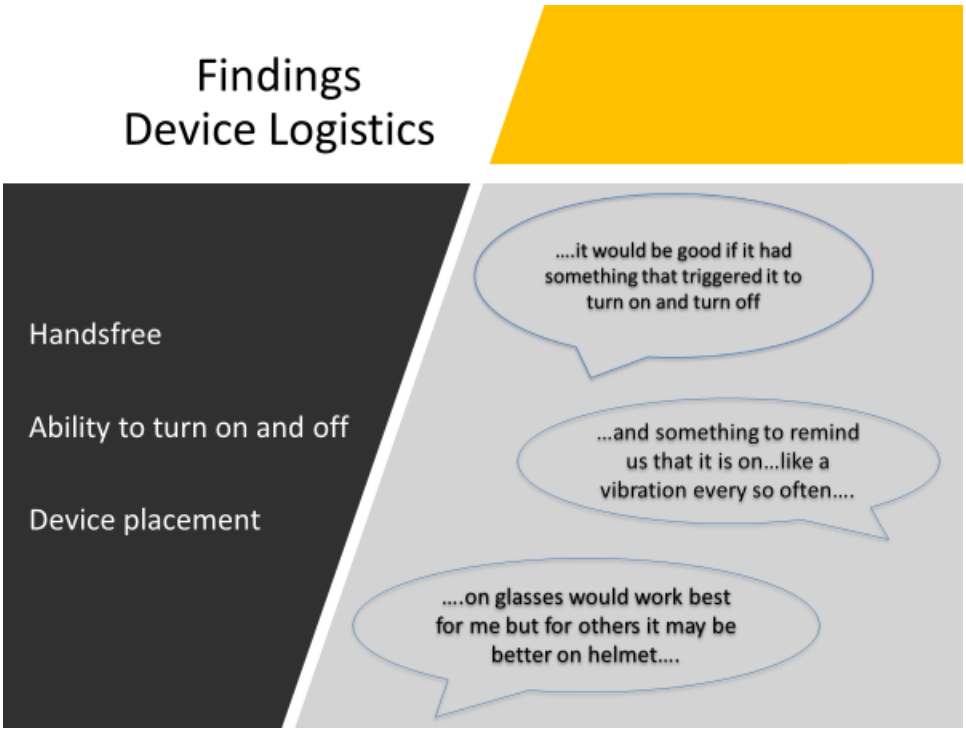
Findings
Information Use



Findings
Information Transmission



Findings
Device Logistics



Conclusions

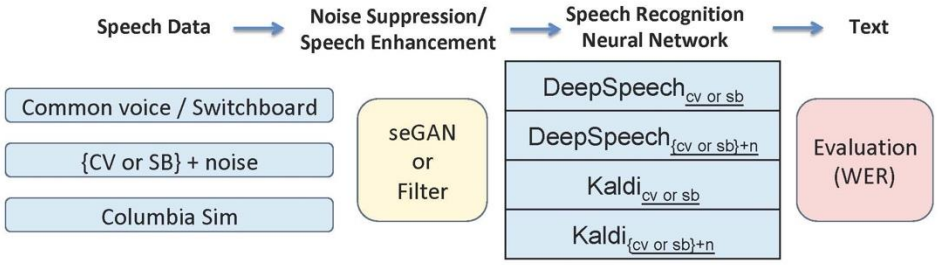
Informed protocol needs for collecting and transmitting data

Suggests information (notes from audio & video) could be useful at multiple phases of care

Audio recognition sophistication for chaotic communication

APPENDIX C - Overview of Speech Recognition Methods and Systematic Performance Assessment studied in the project

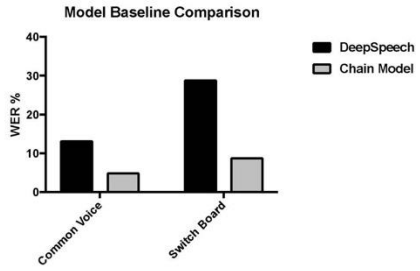
Appendix: Benchmarking Two Leading Open Source Speech Recognition Software (DeepSpeech, Kaldi) with different noise, filters, and enhancement modules



Split speech data into:
Training 85%; Validation 5%; Testing 10%
cv=common_voice;
sb=switchboard;
n=noise

Speech Enhancement Generative Adversarial Network (seGAN) is a widely adopted speech enhancement method

Results

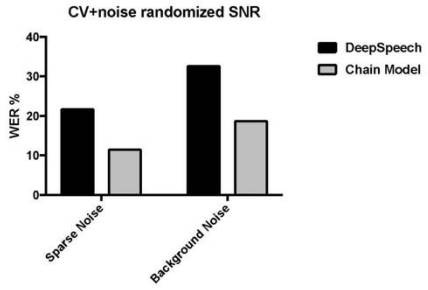


Model	Common Voice	Switch Board
DeepSpeech	13.40%	29.01%
Kaldi Chain Model (w/o augmentation)	5.14%	9.04%
Kaldi Chain Model (with augmentation)	4.65%	9.33%

DeepSpeech and Chain acoustic models were trained by both Common Voice and Switch Board datasets. Word Error Rate (WER) was calculated by using testing data against trained models. Results are shown in both figure and table formats.

Augmentation: a technique that creates larger training data set.
Switch board data didn't achieve further WER reduction with augmentation, probably due to the model had not been fine-tuned yet. The size/amount of the training data is critical!

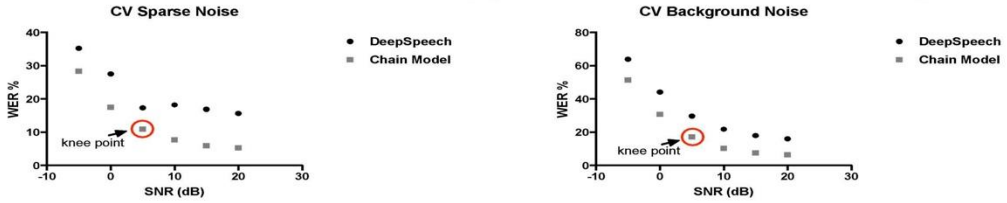
Results



DeepSpeech and Chain acoustic models were trained by Common Voice dataset with either sparse noise or background noise with randomized signal noise ratio (SNR). Word Error Rate (WER) was calculated by using the test data.

Results

Knee point suggested that the model's performance was very sensitive to data with SNR less than 5 dB. We should pay more attention to data within this SNR range.



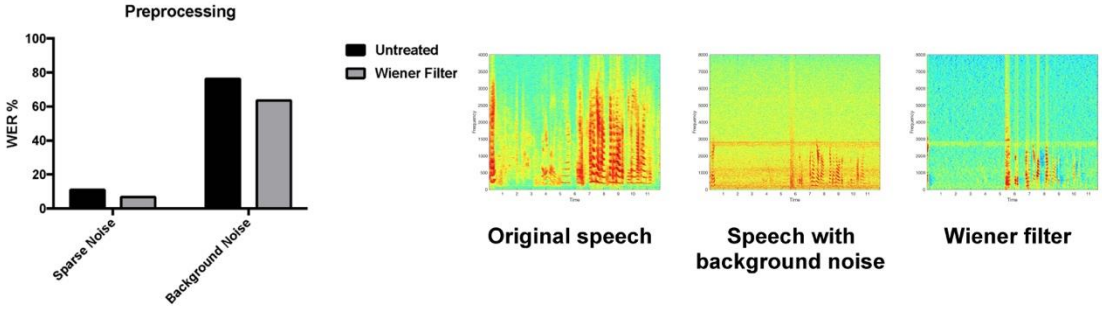
Trained models	-5dB	0dB	5dB	10dB	15dB	20dB
DeepSpeech (test sn)	35.20%	27.55%	17.33%	18.17%	16.90%	15.66%
Kaldi (test sn)	28.30%	17.44%	10.85%	7.68%	5.93%	5.28%
DeepSpeech (test bn)	63.84%	44.09%	29.72%	21.83%	17.94%	15.98%
Kaldi (test bn)	51.34%	30.69%	17.18%	10.18%	7.47%	6.31%

DeepSpeech and Chain acoustic models were trained by Common Voice dataset with either sparse noise or background noise with randomized signal noise ratio (SNR). Word Error Rate (WER) was calculated by using the test data with incremented SNR against trained models.

Results

seGAN data are not available for reporting yet.

Wiener filter showed some degree of improved performance, however, suppression of noise also suppressed speech.



Chain acoustic models were trained by Common Voice dataset with either sparse noise or background noise with randomized signal noise ratio (SNR). Word Error Rate (WER) was calculated by using the test data with incremented SNR against trained models.

Summary and Conclusions

- Compared the baseline performance of two deep learning acoustic models: Mozilla DeepSpeech and Kaldi Chain model (Microsoft). The results suggested that Kaldi Chain model could be a better approach with respect to handling both clean data and data with different types and intensity of battle field noise.
- Performed simple experiments to determine the modification of language model would improve the WER. Language model modification will be a focus in next phase of the project.
- Compared different signal preprocessing methods and our preliminary results shown that seGAN outperformed conventional filters in reducing the noise.

Challenges

Columbia Sim testing against DeepSpeech or Kaldi Chain Models both resulted in undesired results (WER greater than 80%)

Potential reasons being investigated:

- Voice Activity Detection: The Drill data were cut by an un-optimized open source VAD script. The cut piece varies in length and also includes irregular inclusion of pure noise segments.
- The current hardware and software do not sufficiently filter out speakers in the background.
- Speech enhancement techniques have not been completed.
- Language model needs to be further trained with certain lacking pattern recognition.

Directions in next phase of the project:

- Implement machine learning-based VAD.
- Improve recording microphone to better separate different speakers during the 2nd drill.
- Label and analyze speech data in a speaker specific manner for training.
- Continue work on speech enhancement techniques to preprocess drill data.
- Re-design scripts for the next drill based on the desired medical read out form and train extended language model accordingly.

Complete And Resilient Documentation (CARD) for Operational Medical Environments

Kuang-Ching Wang, PhD[1], Ronald Gimbel, PhD[1], Melissa Smith, PhD[1], Marcin Ziolkowski, PhD[1], Williams Jennings, MD[2], Steve Shelton, MD[2], William Gerald, MD[2], Kelley Hawsey, RN[2]

[1]Clemson University, Clemson, SC, [2]Palmetto Health System, Columbia, SC

LEARNING OBJECTIVES

- Learn and discuss the pressing needs and challenges for health record collection in operational environments.
- Understand the state of deep learning based speech recognition and its potential use in health record collection in battlefield.
- Understand the range of GPU compute technology and its use in multiple form factors.
- Understand the major study thrusts to develop, assess and deploy the CARD system.

ABSTRACT

- The project's mission is to demonstrate and validate hands free electronic health data entry that:
  - has reliability in a noisy environment
  - alleviates disruption of care for documentation
  - prevents loss of documentation
- We have proposed a system-oriented approach that:
  - enables resilient hands-free data collection
  - preserves complete documentation
  - presents timely information useful to the medical operation
- We will show that existing technology is adequate if the data record is decoupled from documentation entry
- CARD will show uninterrupted medical workflow by:
  - Preserving complete documentation
  - Presenting timely data relevant to the roles of care

BACKGROUND

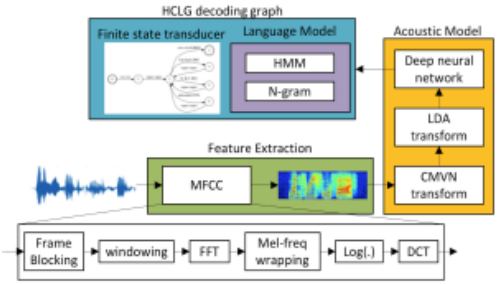
- Existing Natural Language Processing (NLP) solutions are not adequate in battlefield
  - Results in loss of critical information
- Concerns with existing data capture solutions
  - Disrupts medics from delivering care
  - Requires medic-worn devices to be both light-weight and powerful

METHODS

- The project team includes technology researchers, military health system experts, and emergency medical physican leaders
- The project is integrated with the Cerner electronic health record (EHR) system
  - Data will be validated at initial and final stages
- An accredited medical simulation center will be used
  - Multiple levels of care (Role 1, 2, 3) scenarios with military-oriented EMS staff and physicians

- Three paths will be taken in parallel
  - Work flow identification and information requirements
    - Interviews and focus groups will be used
    - Emergency medial physicians, EMS personnel, and medical transport nurses
  - Hardware research
    - GoPro and non-volatile storage
    - GPU platforms
    - Cerner EHR
  - Software Research
    - Building a program and library for NLP based speech recognition and video classification software
- The open architecture assures CARD to be a flexibly extensible and long-term evolvable platform

METHODS (CONT')



RESULTS AND CONCLUSION

The project has been recommended for funding in February 2017. The project's initial focus is on clinical interviews, simulation center drills, platform integration, and speech recognition algorithm development.

Alpha benchmarks for the system are expected by Spring 2018.

AFFILIATIONS

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DISCLAIMER

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Complete and Resilient Documentation (CARD) for Operational Medical Environments

Log Number: DM160374

W81XWH-17-C-0238

PI: Kuang Ching Wang **Org:** Clemson University **Award Amount:** $1,644,510

Study/Product Aims

Our objectives are:

- **Identify the medical workflow** and information needs of battlefield medics and air transport nurses caring for wounded warriors in an operational environment.
- **Develop the platform** for hands free EHR data documentation robust to the environment.
- **Develop natural language processing solution** for multi-stage information extraction.
- **Develop systematic assessment instruments** based on medical workflow efficacy.

Approach

The research targets long-term feasibility of hands free documentation of injury in operational environments from two fronts: Medical and Technological.

- *On the medical front:*
  - Focus groups/interviews
  - Simulation drills (battlefield, en route, field hospital care)
- *On the technology front:*
  - Platform for flexible integration (recording devices, compute devices, and EHR)
  - Decoupled recording and processing + persistent performance improvement.

The study is structured into three parallel thrusts: platform development, software development, and assessment. This figure illustrates the relation of the three thrusts.

Timeline and Cost

Activities	CY 17	18	19
Medical Workflow Studies			
Platform development			
Assessment			
Roadmap development			
Estimated Budget ($K)		$893k	$751k

Updated: (30AUG2018)

Goals/Milestones

CY17-18 Goals – Medical Workflow and Platform Development

- ☐Focus Groups, Drill #1
- ☐Platform Integration
- ☐ Speech Recognition

CY18-19 Goals – Qualitative Assessment and Roadmap Development

- ☐ Video Digest
- ☐Cerner Integration
- ☐Drill #2
- ☐Workflow and HER Assessment

Comments/Challenges/Issues/Concerns

- There are no challenges, issues or concerns at this time.

Budget Expenditure to Date

Projected Expenditure: $1,644,510

Actual Expenditures: $463,129.21 @30AUG2018