SURGE: Smart Ultrasound Remote Guidance Experiment Preliminary Findings

NASA-JSC / Wyle Aerospace Medicine Clerkship

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Presentation outline

Ultrasound in space

SURGE introduction

SURGE design

Results

Next steps
<table>
<thead>
<tr>
<th>Team members</th>
<th>Funding</th>
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<tbody>
<tr>
<td>Scott Dulchavsky (PI)</td>
<td>Part of Phase 3 of the Bracelet Investigation Grant</td>
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<tr>
<td>Victor Hurst</td>
<td>Henry Ford/NSBRI</td>
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<td>Kathleen Garcia</td>
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<td>Ashot Sargsyan</td>
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<td>Doug Ebert</td>
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<td>David Ham</td>
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<tr>
<td>Mary Carvalho</td>
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<td>Sean Peterson</td>
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Why SURGE?

• Exploration-class missions lead to longer communication delays with mission control
• May not always have communication capability to stream real-time ultrasound images
• SURGE explores use of a “just-in-time” learning tool, called OPEL = On-Board Proficiency Enhancer Light as an aid to a hypothetical crew medical officer working autonomously
Inexperienced ultrasound operators

Autonomous operation

Investigate necessary requirements to collect useful ultrasound images
  - Level of experience
  - Amount of training
  - Human factors

Compare to real-time, remote guidance with a communication time delay relating to a lunar mission (5 seconds)
Participants

- No formal ultrasound training
- Less than 2 hours total time using an ultrasound machine
- Mix of medical and non-medical individuals
  - Physicians
  - Biomedical engineers
  - Administrative duties
  - 1 physician astronaut
Study design – 3 groups

**A**  Remote Guidance

**B**  Autonomous OPEL

**C**  Remote Guidance & OPEL

OPEL refers to On-orbit proficiency enhancer light, a computer-based learning tool
## Comparison metrics

<table>
<thead>
<tr>
<th>Fracture assessment</th>
<th>FAST abdomen assessment</th>
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<tbody>
<tr>
<td>• Task completion time</td>
<td>• Task completion time</td>
</tr>
<tr>
<td>• Correctly diagnose fractured limb</td>
<td>• Image quality</td>
</tr>
<tr>
<td>• Confidence in diagnosis</td>
<td></td>
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<tr>
<td>• Image quality</td>
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### Post-experiment questionnaire

• Assessment of training, cue card, computer-based training, remote guidance, difficulty & frustration
• Ultimately, captured ultrasound images will be reviewed and rated by two blinded and independent expert radiologists
• Preliminary assessment performed by un-blinded, non-expert, yet FAST certified family medicine physician
• Not validated
• Rating identical for both the fracture assessment and the FAST abdomen assessment
  – Each view assigned a rating
    • “1” if diagnostic
    • “0” if non-diagnostic
  – Ratings from 4 views summed to give an “Image Quality” rating out of four
What did we find?
Subjects were able to correctly identify fractured limb

| Fractured limb correctly identified |  
|-----------------------------------|---
| Remote Guidance                  | 86% *  
| Autonomous (OPEL)                | 88% *  
| Remote Guidance & OPEL            | 100%  

* 2 out 22 subjects identified a fracture, but in the wrong limb
Guidance improved image quality for fracture assessment

OPEL refers to On-orbit proficiency enhancer light, a computer-based learning tool analyzed using ANOVA: Tukey’s Honest Significant Difference (HSD) Test.
Wide variation on FAST abdomen results

OPEL refers to on-orbit proficiency enhancer light, a computer-based learning tool.

Analyzed using ANOVA: Tukey’s Honest Significant Difference (HSD) Test.
No perceived difference in difficulty or frustration

- Initial scales for Difficulty and Frustration were a Likert scale out of 7 with 1 being “very difficult” and 7 being “not difficult at all”
- Graphs above represent 7 minus the average of each group
- None of the differences were significant
Medically trained subjects obtained better quality FAST images

- No significant difference in FAST task completion times
- No significant difference in either fracture assessment completion times or quality of images
No correlation between FAST ultrasound task completion time and image quality
### Great ideas for improvement obtained by post-experiment questionnaire

#### Overall
- Maintain consistent, plain language
- Reinforce firmer pressure to improve image quality
- Have automatic recognition of internal body structures by ultrasound

#### Pre-experiment training
- Include a “tour” through the human body showing specific organs
- Describe how to get gel out of bottle by shaking it down to the dispersing end

#### Cue card
- Add instructions on how to capture a STILL and a VIDEO LOOP
- Include a description of “SWEEP” = tilting probe one way and then the other to visualize an organ or interface
- Change position of A4 to be more posterior in mid-axillary line

#### Remote guidance
- Limit instructions to 3 steps so as to not get ahead of ultrasound operator
- Provide positive feedback when proper images obtained to aid ultrasound operator confidence
- Share with ultrasound operator what a “positive” scan would show
Many suggestions for improving the FAST component of OPEL

<table>
<thead>
<tr>
<th>FAST abdomen procedure</th>
<th>FAST abdomen video</th>
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<tbody>
<tr>
<td>• Remove medical language</td>
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<tr>
<td>• Better describe orientation of probe and include pictures of orientation</td>
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<tr>
<td>• Better describe how to locate the kidney</td>
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<tr>
<td>• Describe how to manage with rib shadows</td>
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<tr>
<td>• Better describe procedure to visualize heart from sub-xyphoid approach</td>
<td></td>
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<tr>
<td>• Reset depth setting after each position to avoid missing far-field structures</td>
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<tr>
<td>• Include a “problem-solving” section that describes potential maneuvers to attempt to gain the desired image.</td>
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<tr>
<td>• Embed videos in word document at relevant line items</td>
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<tr>
<td>• Expand video to include more still pictures of the desired views with labels describing the target organs and where “free fluid” would appear</td>
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<tr>
<td>• Better describe how to do a SWEEP or “tilt” to visualize an interface</td>
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<tr>
<td>• Emphasize need to have probe nearly parallel with abdomen and tucked under ribs with firm pressure to visualize heart</td>
<td></td>
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<tr>
<td>• Provide examples of “positive” free fluid ultrasound images in video</td>
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<tr>
<td>• Include a “problem-solving” section that describes potential maneuvers to attempt to gain the desired image (i.e., breath holds, bending knees, rotating probe, panning probe)</td>
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Thank you!

- Corrine for providing us with an excellent month at “space camp”
- Wyle for hosting us and providing logistical support
- NASA-JSC and flight docs for excellent teaching and outstanding experiences
- Mary Carvalho, PhD for rapid statistical analysis
- David Ham for technical support
- Victor Hurst IV, PhD, Kathleen Garcia, RDCS, RVT, Ashot Sargsyan, MD, and Doug Ebert, PhD for providing me with an opportunity to participate in such a neat project!