CRISIS IN SPACE – A NEW WAY TO MEASURE COLLABORATION SKILLS USING ONLINE GAMES

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@SaadKha08648111 | #ETCPS19
Competencies to Succeed in the 21st Century
Challenge of Evidence Identification
AI based innovations in Evidence Identification

**Multimodal Analytics (NLP+CV+ML)**

- **Voice:** Calm
- **Facial Expression:** Smiling, Eye Contact
- **Body Posture:** Relaxed

**Overall State:** Engaged
AI based innovations in Evidence Identification

Deep Hierarchical Inference Models

High-level inferences
- Knowledge Assimilation
- Positive Communication
- Resource Sharing

Mid-level representations
- Turn-taking, Engagement, Affect

Low-level features
- Speech, Prosody, Facial Expressions, Gestures
  - SVM
  - HMM
  - HOG
  - Euler Angles
  - MFCC

Multimodal data
- Video
- 3D
- Audio

Measuring Collaborative Problem Solving Skills
Using Games for Education?
Collaborative Game: **Crisis in Space (CIS)**

Task is to repair the International Space Station (ISS) by solving a series of puzzles.

Image Source: GlassLab Inc
Player Interfaces

Operator

Engineer
Gameplay Segments

The game is divided into **Five missions** – a total of **16 tasks** must be completed.

Players alternate roles between missions.
CIS Task: Circuit Board

Operator

Engineer

4 Wires

The circuit board can have 3-6 wires on it. The correct wire will need to be cut or patched in order to successfully complete the alert. Wires are ordered with the first wire at the top left.

When there are 3 WIRES
A. If there are NO BLUE wires, then cut the wire furthest to the right.
B. Otherwise, if the test wire is RED, cut the wire furthest to the right.
C. Otherwise, if 2 or more wires are YELLOW, cut the wire in the middle.
D. Otherwise, cut the wire furthest to the left.

When there are 4 WIRES
A. If there are no BLUE wires and the Orbit Type is Elliptical, cut the wire furthest to the left.
B. Otherwise, if the wire furthest to the left is PURPLE and there are no BLUE wires, cut the second wire from the left.
C. Otherwise, if there is exactly one RED wire, cut the wire furthest to the right.
D. Otherwise, if there is more than one YELLOW wire, cut the second wire from the left.
E. Otherwise, cut the second wire from the right.

When there are 5 WIRES
A. If the second wire from the left is WHITE and the Orbit Type is Circular, cut the single wire to the right of the microchip.
B. Otherwise, if there is more than one RED wire and more than one YELLOW wire, cut the third wire from the left.
C. Otherwise, if there are no PURPLE wires, cut the third wire from the left.
D. Otherwise, cut the second wire from the right.

When there are 6 WIRES
A. If the Orbit Type is Elliptical, and there are no WHITE wires, cut the bottom wire on the
Collaboration in the CIS Game

• Involves **two** inter-related components:

  • **Cognitive**: Traces the phenomenon of macro-cognition wherein team members transform **data** into **information** and then into **knowledge** that enables taking **action** and monitor problem solving.

  • **Socio-Emotional**: Collaboration requires building and maintaining **relationships** among team members within a healthy and open emotional environment.
CPSx Skills Map

- **Cognitive**
  - Individual Knowledge Building
  - Team Knowledge Building
  - Decision Making and Execution
  - Monitoring

- **Socio-Emotional**
  - Leadership
  - Cooperation
  - Relationships
  - Resilience
Experimental Design and Data Sources

CPS Human-Human (X) interaction equipment setup and telemetry data collection.
Players During Gameplay Session
Machine Learning based Evidence Identification and Inference
Multimodal Data Fusion for Annotation and Feature Extraction

https://www.youtube.com/watch?v=QmuLeBKnvF0&list=PLw2QJrKWPYuJe0pS4g91DSEwjiReX03ut
Annotation of ‘high-level’ behaviors
Tracking Player Affective State
Okay, I think I'm live and I see you in the corner of here so you know what I think I'm good. Yeah, start recording the action. Start by clicking on this way have the wrenches in the starting error from left bottom, it's better to the front, left and then right. Okay, go three down and three to the left or how the fires and the upper right corner, but it's one down okay, go write three up, one right, right, that's right no miss one doubt, for me it's all the way to the left, oh, okay, down too. Oh, I can't do that okay, where are you?
NLP Based Discourse Analysis

- **Questions** ("What did you say?")

- **Describe task to partner** ("I see symbols"; "There is a tool and a fire")

- **Monitoring time and strikes** ("We only have five seconds left")

- **Closing Loop** ("Roger that")

- **Sentiment Analysis**
  - Both from Keywords (+/-) and Waveform (pitch, tonality, etc.)

\[ |g(s)| |g(t)| \cos \theta \]

Transformer Networks, e.g. BERT
CPSx Skills Map

Cognitive
- Individual Knowledge Building
- Team Knowledge Building
- Decision Making and Execution
- Monitoring

Socio-Emotional
- Leadership
- Cooperation
- Relationships
- Resilience

CPSX Skills

Individual Information Gathering
Individual Information Synthesis
Information Exchange
Shared Knowledge
Suggest Course of Action
Implement Action
Evaluate Solution Quality
## CPSx Skills Map

<table>
<thead>
<tr>
<th>Category</th>
<th>Skill</th>
<th>Subskill</th>
<th>Indicator</th>
<th>Revers</th>
<th>Tag</th>
<th>Unsupervised Tag</th>
<th>Reality on</th>
<th>Description</th>
<th>ELAN CV</th>
<th>Modality</th>
<th>Detailed-Tagging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-Emotional</td>
<td>Leadership</td>
<td>Initiative</td>
<td>No</td>
<td>Share in</td>
<td>Task-State</td>
<td></td>
<td>Somewhat</td>
<td>states task-related information without being prompted</td>
<td>Cognitive_Speech</td>
<td>Speech Act</td>
<td>Task-State</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Leadership</td>
<td>Initiative</td>
<td>No</td>
<td>Instructs/directs action</td>
<td></td>
<td>Somewhat</td>
<td>Role, event logs</td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td>Task-Direct</td>
<td></td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Leadership</td>
<td>Initiative</td>
<td>No</td>
<td>Suggests</td>
<td></td>
<td>FALSE</td>
<td></td>
<td></td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td>Task-Suggest</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Responsiveness</td>
<td>No</td>
<td>Respond/Answer</td>
<td></td>
<td>FALSE</td>
<td></td>
<td>Answer partner’s question</td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td>Task-Resp</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Responsiveness</td>
<td>No</td>
<td>Acknowledgement (okay, uh-huh)</td>
<td></td>
<td>Somewhat</td>
<td></td>
<td>Key words, punctuation + acoustic features</td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td>Task-Ack</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Attentiveness</td>
<td>No</td>
<td>Ask question</td>
<td></td>
<td>Somewhat</td>
<td></td>
<td></td>
<td>Cognitive_Speech</td>
<td>Speech Act</td>
<td>Task-Ack</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Attentiveness</td>
<td>No</td>
<td>Student asks for social-, affect-related information</td>
<td></td>
<td>FALSE</td>
<td></td>
<td>Team Ask</td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td>Team-Ask</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Attentiveness</td>
<td>No</td>
<td>Student answers questions or acknowledges statements related to social/affect information</td>
<td></td>
<td>FALSE</td>
<td></td>
<td>Team Answer/Team Acknowledge</td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td>Team-Answer/Team-Ack</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Attentiveness</td>
<td>No</td>
<td>Gaze to partner</td>
<td></td>
<td>TRUE</td>
<td></td>
<td></td>
<td>SE_Gaze</td>
<td>Gaze</td>
<td>Skype AOI</td>
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<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Attentiveness</td>
<td>Yes</td>
<td>Look away</td>
<td></td>
<td>TRUE</td>
<td></td>
<td>Distance from screen reflects attentiveness and engagement</td>
<td>SE_Emotion</td>
<td>Facial</td>
<td>FaceReader</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Cooperation</td>
<td>Attentiveness</td>
<td>No</td>
<td>Dist. from screen change</td>
<td></td>
<td>TRUE</td>
<td></td>
<td></td>
<td>SE_Emotion</td>
<td>Facial</td>
<td>FaceReader</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Display of Emotion</td>
<td>No</td>
<td>Laughter</td>
<td></td>
<td>TRUE</td>
<td></td>
<td>DL laughter detection algorithm similarity to anchor sentences</td>
<td>SE_Prosodic</td>
<td>Prosodic</td>
<td></td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Display of Emotion</td>
<td>No</td>
<td>Positive exclamation</td>
<td></td>
<td>Somewhat</td>
<td>e.g. “yippee”</td>
<td>SE_Prosodic</td>
<td>Prosodic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Display of Emotion</td>
<td>No</td>
<td>Negative exclamation</td>
<td></td>
<td>Somewhat</td>
<td>e.g. “Oh no!”</td>
<td>SE_Prosodic</td>
<td>Prosodic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Display of Emotion</td>
<td>No</td>
<td>Smile</td>
<td></td>
<td>TRUE</td>
<td></td>
<td></td>
<td>SE_Emotion</td>
<td>Facial</td>
<td>FaceReader</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Display of Emotion</td>
<td>Yes</td>
<td>Frustration/Anger/Negative Emotion</td>
<td></td>
<td>TRUE</td>
<td></td>
<td>Reverse code</td>
<td>SE_EMotion</td>
<td>Facial</td>
<td>FaceReader</td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Display of Emotion</td>
<td>No</td>
<td>Confusion</td>
<td></td>
<td>Somewhat</td>
<td></td>
<td></td>
<td>SE_Speech</td>
<td>Speech Act</td>
<td></td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Encouraging</td>
<td>No</td>
<td>Apology</td>
<td></td>
<td>Somewhat</td>
<td></td>
<td></td>
<td>SE_Prosodic</td>
<td>Speech Act</td>
<td></td>
</tr>
<tr>
<td>Socio-Emotional</td>
<td>Rapport</td>
<td>Encouraging</td>
<td>No</td>
<td>Success Gestures</td>
<td></td>
<td>Somewhat</td>
<td>Hand detection and smile or positive</td>
<td>SE_Gesture</td>
<td>Gesture</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ACTNEXT
Inference Model – Accumulate Evidence of CPS Skills

- **Individual Knowledge Building**
  - Individual Information Gathering
  - Individual Information Synthesis

- **Team Knowledge Building**
  - Information Exchange
  - Shared Knowledge

- **Decision Making and Execution**
  - Suggest Course of Action
  - Implement Action

- **Monitoring**
  - Evaluate Solution Quality

**Actions**

- Locate the Circuit task (E)
- Ask question (E/O)
- Name the Circuit task (O)
- State number, color and sequence of wires (O)
- Map number, color and sequence to rule (E)
- State wire to be cut (E)
- Cut wire (O)
- Assess solution (E/O)
- Monitor time and/or strikes (E/O)
- Share information from partner’s viewpoint (E/O)
## Pilot Studies: CPSX Game Data Collection

<table>
<thead>
<tr>
<th>Type of Data</th>
<th>Attributes of Data</th>
</tr>
</thead>
</table>
| **Survey Data** | • Demographics: Gender, Game-play experience  
  • CPSx Survey  
  • Tessera SEL |
| **In-game Data** | • Chat logs + Audio = Transcript  
  • Video (User camera & Screen Recording)  
  • Game Logs/Telemetry  
  • Eye Tracking & Areas of Interest |
CPSx Pilot 2: Iowa City area schools
Post Gameplay Survey

How would you rate your experience in terms of...

- Fun
- Stressful
- Exciting
- Collaborative
- Difficult

Categories:
- 1 - Very Low
- 2 - Low
- 3 - Moderate
- 4 - High
- 5 - Very High
Post Gameplay Survey

**How well did you know your partner before the game?**

113 responses

<p>| | | | | | |</p>
<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 (17.7%)</td>
<td>17 (15%)</td>
<td>17 (15%)</td>
<td>22 (19.5%)</td>
<td>37 (32.7%)</td>
</tr>
</tbody>
</table>

**How well do you feel you know your partner now?**

113 responses

<p>| | | | | | |</p>
<table>
<thead>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8 (7.1%)</td>
<td>11 (9.7%)</td>
<td>24 (21.2%)</td>
<td>32 (28.3%)</td>
<td>38 (33.6%)</td>
</tr>
</tbody>
</table>
Feedback & Reporting interface

<table>
<thead>
<tr>
<th>id</th>
<th>age</th>
<th>gameHour</th>
</tr>
</thead>
<tbody>
<tr>
<td>scott</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>emma</td>
<td>21</td>
<td>20</td>
</tr>
</tbody>
</table>

**summary**
- information gathers
- information exchange
- information synthesis
- leadership
- rapport
- resilience

**information gathers**
Visual search for relevant elements in the task
KCRG Coverage

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