Modeling Performance for Marksmanship Training Tools

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Purpose

• Marksmanship skills are critical for the U.S. Marine Corps but are expensive, time-consuming and labor-intensive to develop

• Shooters with skill deficiencies cause bottlenecks in the training process, as instructors must take additional time to remediate

• Skill deficiencies can be difficult to diagnose and multiple instructors may be required to provide remediation
Purpose

• Provide an automatic evaluation of fundamental marksmanship skills to support instructors

• Data Source: Rifle-mounted aim-trace sensor
Data Collection System
Project Goals

Improved Instructor Experience

Algorithm Development and Validation

Prone Aim

<table>
<thead>
<tr>
<th>Aim (mm)</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>100</td>
<td>0.08</td>
</tr>
<tr>
<td>200</td>
<td>0.06</td>
</tr>
<tr>
<td>300</td>
<td>0.04</td>
</tr>
<tr>
<td>400</td>
<td>0.02</td>
</tr>
<tr>
<td>500</td>
<td>0.01</td>
</tr>
<tr>
<td>600</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Needs Analysis

• US Marine Corps Weapons Training Battalion Instructors were interviewed about information and features that would assist in training.

• As a result of these interviews, several features were incorporated into software development:
  • Commenting function so instructors can add comments to shots
  • Video playback of shots were included
  • Timeline of shot was color-coded
  • Legends of markers were added
  • Icons were updated to be more intuitive
Software Development & Testing

• Data Collection and Data Management software designed to display the same visualization (good, moderate, poor), use the same cutoff scores, and maintain same ‘look and feel’

• Systems both tested for usability throughout the development process
  • Usability conducted with Weapons Training Battalion instructors at Quantico, VA and Weapons and Field Training Battalion instructors at Camp Pendleton, CA
  • Systems updates include: new icons, new timeline colors, shot grouping visualization
Software Development

Data Collection Software

Data Management Software
Data Collection & Model Development

• 3 Data Collection Events
  • Quantico, VA
  • Camp Pendleton, VA
  • Quantico, VA

• Experts and novices took 10 shots in each shooting position at dry fire simulated distance 200 yards

• Performance was used to determine whether the system can discriminate between experts and novices and to create evaluation criteria
Shooter Performance Data Collection 1

- US Marine Corps Shooters at Quantico, VA
- Expert Shooters (n = 7)
- Novice Shooters (n=8)
- 10 shots in each position (prone, sitting, kneeling, standing)
Prediction of Competency Level

Step 1: Build Model
- **Build Model**
- **Novice Data**
- **Train model (Linear Discriminant Analysis)**
- **Novice**
- **Train model**
- **Expert Data**
- **Expert**

Step 2: Classify Shooter
- **Classify Shooter**
- **Novice**
- **Trained model**
- **Expert**
- **Classify Shooter: Novice or Expert**

Lower scores indicate better performance
Predict Competency Level

- Prone Prediction Accuracy: 87%
- Sitting Prediction Accuracy: 80%
- Kneeling Prediction Accuracy: 87%
- Standing Prediction Accuracy: 100%

- Shooters can be accurately classified as novices or experts, on average, 89% of the time based on data from other shooters.
Modeling Individual Skills

- Skills: Aim, Trigger Control, Hold
- Firing Positions: Prone, Kneeling, Sitting, Standing
- Scores were bootstrapped 5000 times to generate means and 95% confidence intervals
- Cutoff scores need to be created to evaluate performance as good, medium, or poor
Performance statistics (mean, 95% CI) were used to create cutoff scores. These cutoff scores were incorporated into software and visualized in the user interface to provide diagnostic information about shooter performance.
Shooter Performance Data Collection 2 & 3

Data Collection 2

12 Experts, 10 Novices at Camp Pendleton, CA

• 10 shots in each position (prone, sitting, kneeling, standing) at simulated distance 200 yards

Data Collection 3

13 Experts, 13 Novices at Quantico, VA

10 shots in each position (prone, sitting, kneeling, standing) at simulated distance 200 yards
Updates

- Data from all data collection sites were collapsed, expert and novice scores were bootstrapped to generate new performance distributions.
- Moderate distribution was created by combining novice and expert scores.
- Criterion Scores were updated to reflect combined data.
Questions?
Backup
2. Individual Skills

- Experts perform better than novices across all skills
- These differences are greatest in the standing position

**Aim Scores**  
**Hold Scores**  
**Trigger Control Scores**

Lower scores indicate better performance  
Error Bars Represent 95% Confidence Intervals
Individual Skills

• Performance is dramatically worse as shooters move into standing position

Lower scores indicate better performance
## System Updates

<table>
<thead>
<tr>
<th>Result</th>
<th>Evaluation Effect</th>
<th>System Updates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skill scores differ substantially based on shooting position.</td>
<td>The same skill score means different things depending on the position. For example, a ‘good’ score in standing is ‘poor’ in prone.</td>
<td>Updated the interface so that the user can select shooting position. The cutoff scores to evaluate performance differ depending on shooting position.</td>
</tr>
<tr>
<td>Skill scores differ substantially based on relative expertise.</td>
<td>Novices judged by an ‘expert’ standard may appear worse than they really are.</td>
<td>Updated the interface so user can select relative expertise (novice, moderate, difficult) of the shooter. Cutoff scores differ based on expertise level.</td>
</tr>
</tbody>
</table>