Characterization of the Optical Computer Aided Training (OCAT) system: Novel application of a training aid for small arms human performance research and development

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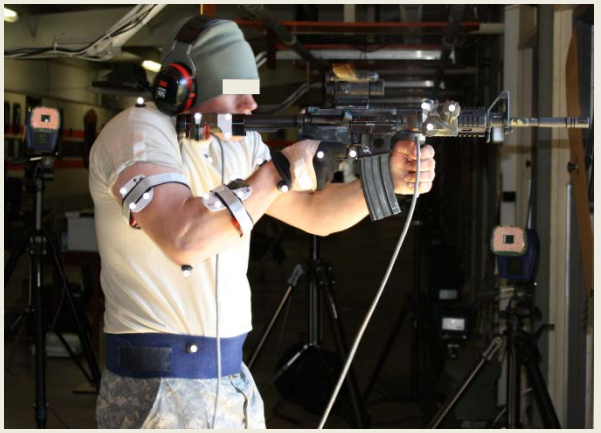
Mission and Project Background

ARL HRED Dismounted Warrior Branch (DWB)

- *Basic/applied research and development*
- *Human performance and human factors assessment*
  - *small arms weapons systems*
  - *target engagement, marksmanship*
  - *biomechanics, Soldier worn/carried equipment*

Characterization of the Optical Computer Aided Training (OCAT) system

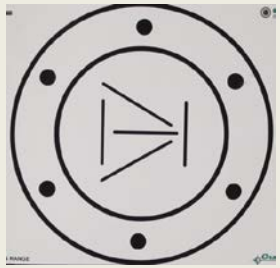
- *Purpose*
  - *Target engagement scoring during small arms assessments and experimental trials*
- *Metrics*
  - *Location of miss and hit (LOMAH) vs. hit/miss only*
  - *Performance comparison with alternate methods*
  - *Subsonic, high rate of fire applications*



Optical Computer Aided Training System (OCAT)

- *Training aid for civilian shooting sports market*
  - *Adapted for experimental data collection*

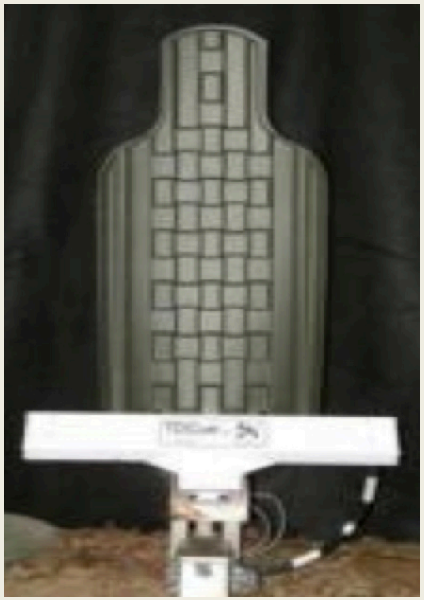
- *Components*
  - *Laptop*
  - *Web camera and spotting scope*
  - *Automated scoring algorithm*



- *User interface*
  - *Experimental condition assignment*
  - *File organization and storage*
  - *Rapid calibration*

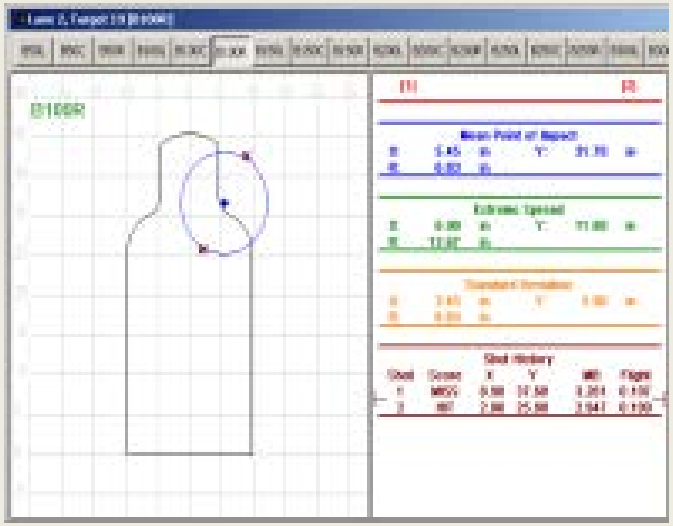
- *Data Acquisition Procedure*
  - *Set up target*
  - *Designate area of interest*
  - *Assign point of aim (origin) based on physical target characteristics, and fire*

ACOUSTIC Scoring



- ***Pros***
  - *rapid data acquisition*
  - *large data sets*
  - *high measurement precision within weapon effective range*
  - *scoring of target misses*

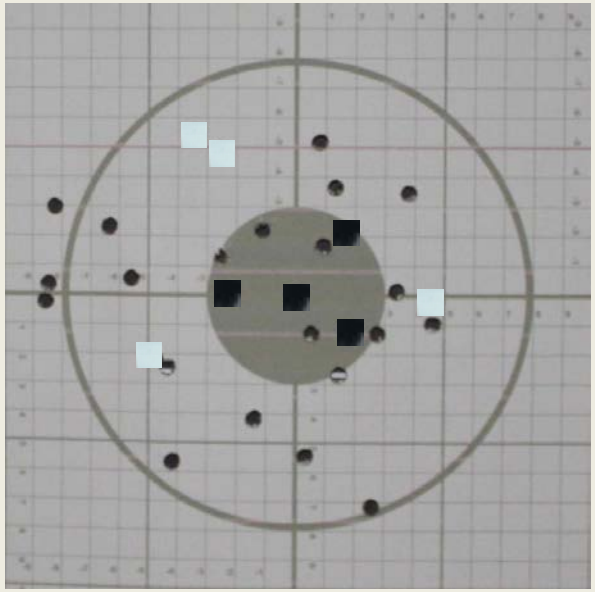
- ***Cons***
  - *measurement precision degrades as projectile approaches weapon effective range*
  - *supersonic projectiles only*
  - *high maintenance costs*
  - *potentially cumbersome to program/operate*



MANUAL Scoring

- ***Pros***
  - ***risk of data loss is low***

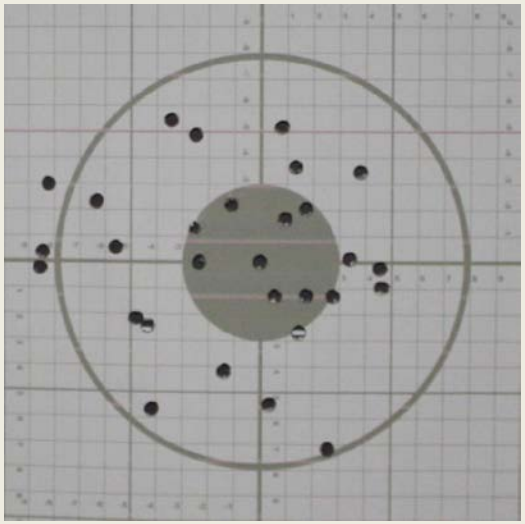
- ***Cons***
  - ***very slow***
  - ***low measurement precision***
  - ***logistically cumbersome***

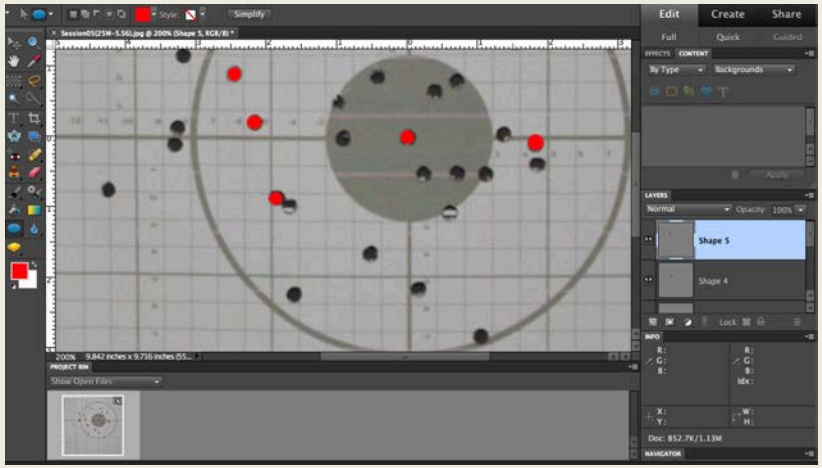


DIGITAL Scoring

- ***Negative***
  - ***very slow***
  - ***potential image capture requirement***
  - ***logistically cumbersome***

- ***Positive***
  - ***high measurement precision***



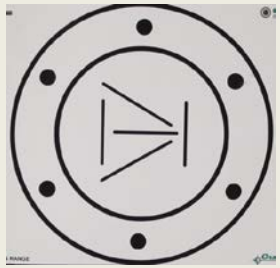


Does the physical span of the hole (i.e., perforation diameter) affect scoring accuracy?

- ***Four (4) ammunition types (and corresponding weapon systems) to vary diameter of hole for the hit***

Does the distance between the camera/scope and target affect scoring accuracy?

- ***Five (5) camera/scope-target distances: 10-25-50-75-100 meters***



How well does optical scoring accuracy correlate with digital scoring accuracy?

- ***Paper target on plywood backer/frame***
- ***30-round groups, spread evenly across target quadrants***
- ***Paper target image capture, Cartesian coordinate (x,y) hit locations digitally scored***

How reliable is hit/miss capture rate across targets?

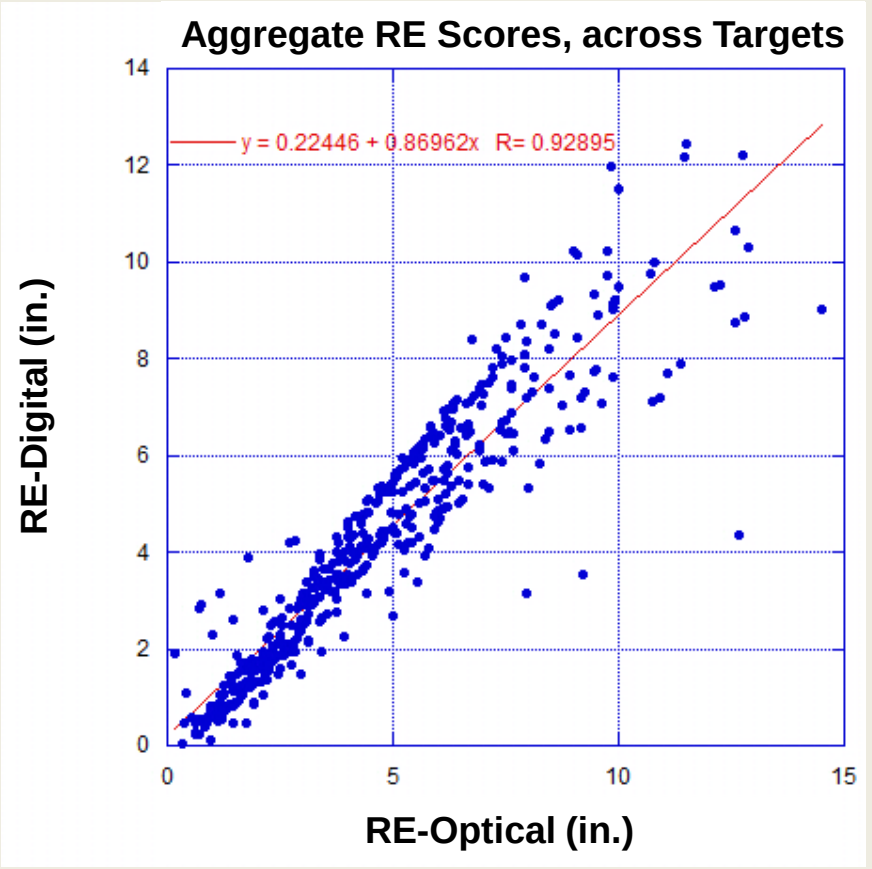
- ***Proportion of shots fired to shots captured***

Results: Accuracy

Pearson's Product Moment Correlation Coefficient (r) for Optical vs. Digital Scoring across Targets

Scope/Camera to Target Distance

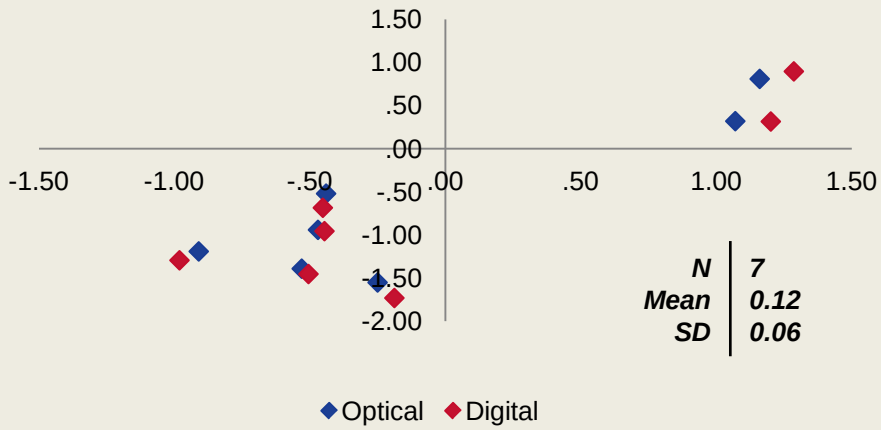
Perforation Diameter	10 M	25 M	50 M	75 M	100 M
5.56 mm	0.960	0.990	0.980	0.996	0.998
6.8 mm	0.986	0.843	0.960	0.976	0.986
7.62 mm	0.970	0.976	0.963	0.986	0.960
9 mm	0.966	0.963	0.963		



Variability for scoring accuracy as a function of ammunition type (i.e., perforation diameter) or camera/scope-to-target distance?

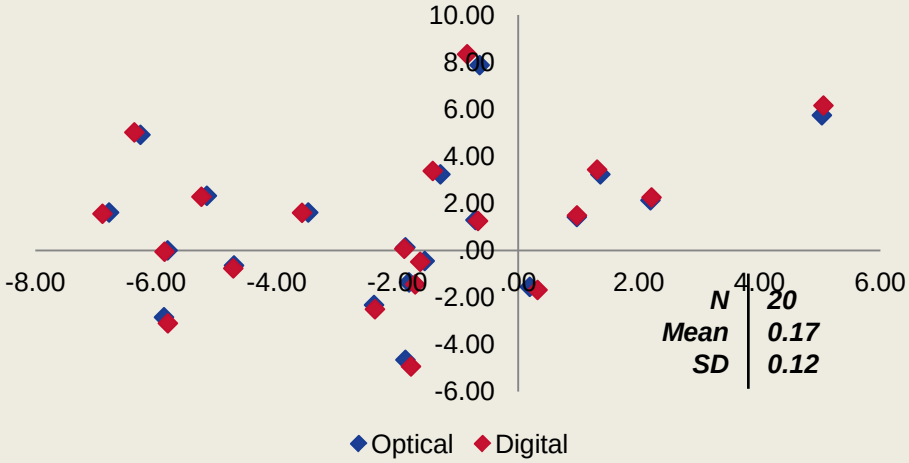
- ***Pearson's r: strong across target sessions, irrespective of ammunition type used or placement of camera/scope relative to target***

Target 03 - 7.62 mm, 10 M



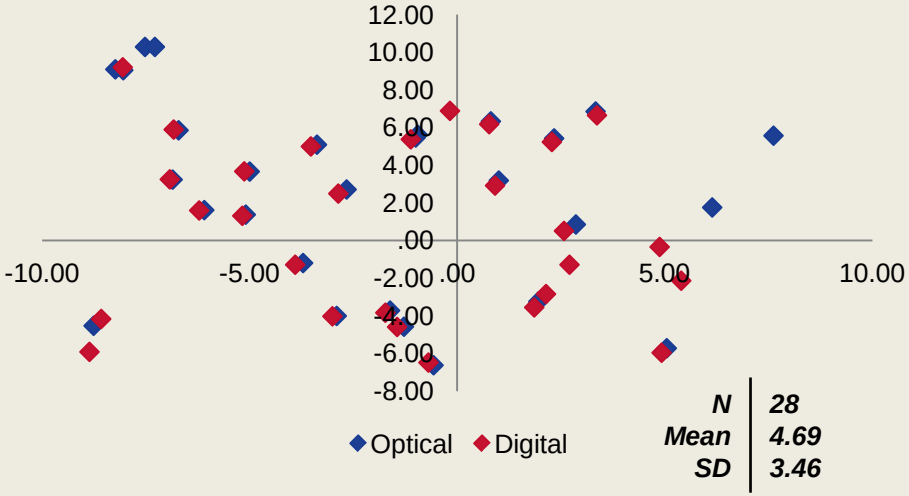
N	*7*
Mean	*0.12*
SD	*0.06*

Target 16 - 5.56 mm, 100 M



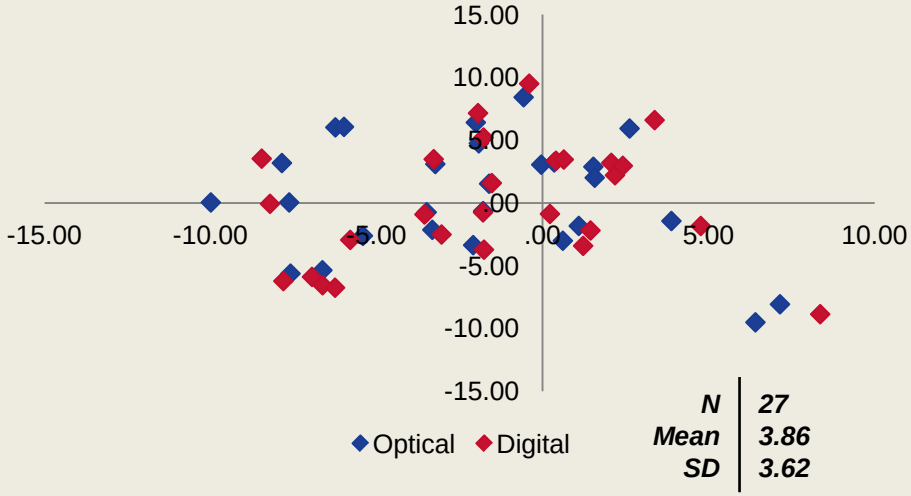
N	*20*
Mean	*0.17*
SD	*0.12*

Target 09 - 5.56 mm, 50 M



N	*28*
Mean	*4.69*
SD	*3.46*

Target 15 - 7.62 mm, 75 M



N	*27*
Mean	*3.86*
SD	*3.62*

Results: Reliability

Error Sources

- *Scope movement due to wind, vibration*
- *Interference from sunlight (ambient IR) – shadowing*
- *Splintering of backer creating tears, hole deformation*

Proportion of Hits Captured for Optical Scoring across Targets

Scope/Camera to Target Distance

Perforation Diameter

	10 M	25 M	50 M	75 M	100 M
5.56 mm	0.93	0.67	0.93	1.00	0.67
6.8 mm	0.90	0.90	0.90	0.87	0.97
7.62 mm	0.23	0.87	1.00	0.90	0.80
9 mm	0.70	1.00	1.00		

Mitigation

- *Dampened movement on the spotting scope/camera by suspending a weight*
- *Shrouded the target to maintain consistent ambient lighting, resulting in higher hit capture rates*
- *Used Coroplast backer to prevent wood splintering*

Conclusions

- ***Potentially viable technology for data collection during human performance, weapon system experimental trials (accurate)***

- ***Mitigation of camera/scope movement and protection from ambient light variability a requirement during data collection, otherwise scoring reliability, accuracy variability is unacceptable***

- ***Optical Scoring***
  - ***faster than manual scoring***
  - ***potential accuracy on par with digital, acoustic scoring***

- ***No projectile velocity-dependent loss of fidelity due to shooter-target range or subsonic ammunition selection (such as when employing an acoustic system)***
  - ***both subsonic and supersonic munitions are viable options when using optical targetry***

Future Efforts

- ***Assessment of reliability with refined movement mitigation***
- ***Data capture for rapid fire, burst and near-synchronous (e.g., shotgun) shooting sequences***
- ***Data capture for multiple targets engaged in close temporal contiguity (e.g., multiple shooters engaging distinct targets)***
- ***Examine the effect of scope/camera-to-target eccentricity on scoring accuracy***
- ***Examine near-keyhole target hit fidelity (since patterns were intentionally spread across target quadrants)***

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