A NEXT GENERATION SMALL ARMS FIRE CONTROL SYSTEM

NDIA 2016 ARMAMENTS SYSTEMS FORUM

BENJAMIN BACHRACH, PHD.
PAUL SHIPLEY
RICHARD LEBLANC
ZACHARY KULIS
MUN WAI LEE, PHD

PENG YANG, PHD
NARESH CUNTOOR, PHD
MICHAEL BADAMO
ADAM HARTMAN
ALI NAMAZI, PHD.

MARK STEVENSON
PHILLIP BERKOWITZ
BO ENGEL
TERRYL GRIMM

Intelligent Automation, Inc.
15400 Calhoun Drive, Suite 400
Rockville, MD 20855
Intelligent Automation, Inc.

Company Overview

- Founded in 1987
- Woman-owned small business
- Headquartered in Rockville, MD
- 150+ Professional staff
- $32M+ revenue for 2015

Locations

- Rome, NY
- Rockville, MD
- Hampton, VA
- Orlando, FL

IAI is focused on developing innovative technologies from concepts to fully-functional prototypes, and in transitioning our technology to products, government programs, and industry partners who have a strong marketplace position.
IAI Small Arms/Handheld EO Systems

- Development of motion-based and appearance-based target detection and tracking algorithms leveraging VIS/NIR and LWIR data.
- Development of small arms fire control system prototypes equipped with target detection and tracking and steerable laser range finder (three generations)
- Development and implementation of SWaP-efficient image processing computational platforms.
- Development of stabilized laser designator for handheld operations.
MOTIVATION AND CONOPS
VPR: Video-based Precision Ranging (JSSAP)

Develop and demonstrate technology that will a) improve first strike accuracy by providing integrated laser range finding and ballistic solution, b) decrease time to engagement.
Target Detection and Range Acquisition

An ideal solution would:

• Assist the soldier in the detection and tracking of difficult moving targets
• Assist the soldier in compensating for weapon wobble and target motion (i.e. stabilizing and pointing the LRF at the target automatically)
• Continuously acquire the range to multiple targets, without the need for user intervention (unless desired)
• Predict the range and position of the target at the time the weapon is fired based on target tracking and ranging history (thus providing the ballistic computer the most accurate information possible; generating an accurate ballistic reticle)

The Video-based Precision Ranging (VPR) small arms fire control system implements all these capabilities by:

• Using machine vision, multiple targets are simultaneously and automatically detected and tracked.
• A steerable laser range finder automatically obtains an accurate range for each target
Target Detection and Range Acquisition

### Conventional Approach

- **User** detects targets
- **User** aims weapon at targets (LRF reticle)
- **User** requests range to target
- **User** holds LRF reticle on target
- **Individual** ballistic solution is generated

### VPR Approach

- **Zero reticle**
- **LRF reticle**

- LRF automatically steered towards all detected human targets; range computed.

### Conventional CONOPS

<table>
<thead>
<tr>
<th>User detects targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Targets are automatically detected via machine vision algorithms</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User aims weapon at targets (LRF reticle)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ranges are automatically acquired and updated by agile steerable LRF for all targets in FOV</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>User requests range to target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ballistic solution generated and continuously updated</strong></td>
</tr>
</tbody>
</table>
VPR Demonstrator Overview

**Performance Characteristics**
- VIS and LWIR imaging systems
- LRF Range – 1,200m*
- LRF Accuracy – ±1m at 1,200m
- Magnification – 3.3x, 6.6x
- Display Resolution – 1280 x 1024
- Field of View – 7.6° x 6.1°, 3.8° x 3.1°
- Eye Relief – 2.0”, 3.0”
- Line of Sight above Rail – 1.5”

*800m to human size target
VPR Demonstrator Overview

VPR on 7.62mm Cased Telescoped Machine Gun, TEXTRON Systems

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited
HOW WE DO IT

Target Detection and Tracking
Example 1: Targets at 600 meters
Example 2: Target at 600 meters
HOW WE DO IT

Robust Image Stabilization
Inertial + Vision-based Stabilization

Robust stabilization with respect to inertial reference frame

Crosshairs are not stabilized!!

Raw footage
Fov: 12.4 deg x 9.9 deg
Resolution: 640 x 480
30 fps

Gyro + vision-based stabilization
Real time processing

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited
Inertial + Vision-based Stabilization

Robust stabilization with respect to inertial reference frame

Crosshairs are not stabilized!!

Raw footage
Fov: 12.4 deg x 9.9 deg
Resolution: 640 x 480
30 fps

Gyro + vision-based stabilization
Real time processing

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited
HOW WE DO IT

Laser Range Finder/Marker Beam Steering and Stabilization
**VPR Steerable LRF Modules**

**Phase I Prototype (CSW)**
Range to human size target: 1,200m
Government Evaluated for:
- Ranging accuracy and repeatability
- Steering accuracy and repeatability
- Shock survivability (M4 simulator)

**Phase III Prototype (IW)**
Range to human size target: 800m
Government Evaluated for:
- Ranging accuracy and repeatability
- Steering accuracy and repeatability
Avon Park, FL, TNT-13.2

Target 1: Equivalent to Toyota pickup at 500 m
Target 2: Equivalent to Toyota pickup at 1,000 m

DISTRIBUTION STATEMENT A: Approved for public release; distribution is unlimited
Outdoors: Avon Park, FL, TNT-13.2

- Target 2: Equivalent to Toyota pickup at 1,000 m
- Stabilization engaged; Operator in sitting, unsupported position.
- Un-stabilized not shown because beam would very rarely hit the target
Using errors (motion) from the video, an actuator moves an optical element to counter-steer the laser.

Video: Avon Park, FL, TNT-13.2

Approximate Bounding Box
Indoors: Stabilized Laser

- View at the target
  - Untrained user, unsupported
  - Purposely aggressive jitter while stabilized, trying to lase the target when not stabilized
  - **Stabilization is engaged** when a green square appears in the user’s view video (see caption)
  - The green square indicates the boundaries of achievable steering

- User’s view (eyepiece)
VPR Status and Future Work

In addition of target detection and steerable LRF functionality, the VPR demonstrator provides a flexible platform for evaluation of capabilities such as:

- Small Arms closed loop fire control
- Capability enhancement of Remote Weapon Station (RWS)
- Long Range Facial Recognition
- Small Arms Cooperative engagement
- Identification of Friend or Foe
- Etc.

TPOC: Benjamin Bachrach, PhD.
Vice President
Email: bach@i-a-i.com
phone: (301) 294-5237
Innovative solutions to meet your technical challenges ….