

Digital Firing, a new way of training

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ABSTRACT

Current small-arms training solutions still have a number of limitations and drawbacks. Often based on laser technology, instrumented screens and closed rooms are required which limit the operational capabilities. The calibration of such systems is also often complicated, involving time consuming adjustment. In case of live training systems in large open areas, a standard laser solution shows occultation and accuracy problems (e.g. partitions, leaves...) and requires instrumentation of all potential targets. In our research, we have found that a typical standard camera can be used to replace laser technology and address most of these issues.. Calibration, shooting direction and firing result are digitally determined through patented algorithms that provide a complete analysis of the firing event and associated performance. Ballistics models take into account ammunitions, gun parameters and meteorological conditions. In case of multi-players configuration, there is no more need of synchronization and limitation in the number of trainees. Targets can either be fixed targets, virtual entities displayed on projection screens or even mobile entities in a real environment, indoor or outdoor. There is no need for a digital twin of the environment. Each individual trainee analysis report is transferred to the Exercise control (Excon) station for further debriefing. Artificial Intelligence (AI) is then used to go deeper in the analysis (target recognition, gunner attitude, gun handling, aiming process...) and alleviate the instructors' workload by providing valuable information. In case of operational scenario involving several trainees potentially on opposing sides, AI will also be used to provide to the instructor an evaluation of the collective team behavior. This paper will describe the technical approach with its main principles and experimentation results conducted with the French and German Forces. The next evolution steps will then be presented.

ABOUT THE AUTHORS

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INTRODUCTION

Force-on-Force and firing training solutions for marksmanship and shooting skills have existed for many years. Modern versions are available but present training needs require new solutions.

Indeed, beyond the standard marksmanship training, there should be no limitations in terms of operational context (indoors or outdoors, shooting through doors and walls...) when present systems can't work because of the commonly-selected laser technology or simply because they are operated in small spaces which do not allow large free movement.

For more than two years, Thales has been developing a new patented solution that draws upon the latest technologies which will overcome all present limitations.

This paper presents the development of the solution that will ultimately lead to the replacement of the solutions based on laser technology. Current state, results and performances will be discussed then a roadmap will be presented.

BACKGROUNDS

Lasers have been used as a pointer for small-arms training for more than 4 decades, though it has a number of shortcomings, both in the force-on-force case and the virtual weapon training system.

In classical force-on-force training, the trainees are equipped with heavy equipment comprised of weapon-mounted laser transmitters that send one or more coded-laser pulses and a special vest/harness/helmet with laser detectors. On higher end system, a communication system also sends the status and position of the players to the Exercise control station (Excon).

The principle is that one or more detectors need illuminating to sense arriving pulses to register a shot and indicate a hit or a near miss. No ballistic effect can easily be simulated as laser beams travel in a straight path. Obstacles like thin walls, foliage or even a clear window are problematic as they hinder laser pulses from reaching detectors. Furthermore, trainees are likely to become "immortal" if their detectors get dirty or covered in mud or dust.

Laser-based systems also have issues at great distance. The technology does not permit ballistic calculations and lacks precision as laser beams diverge and form "cones" that eventually cover a fairly large area. Some systems use multiple lasers with different aperture angles to mitigate the problem but it cannot be avoided completely.

Aligning the weapon barrel and calibrating the laser transmitters is a time-consuming task that requires expertise. It requires fiddling iteratively with the barrel and the laser alignment mechanism until the laser registers well on a special alignment target.

The use of lasers in standard virtual weapon training systems does not suffer from most of these limitations. Lasers generally serve here as a pointing device against a screen displaying a virtual scene with avatars. Generally, a fast IR camera monitors the screen and registers the laser spots positions. Ballistics and advanced attrition can be simulated; calibration is easier as the screen is close to the trainees.

Two problems still exist. These systems generally require a rather dark controlled light environment to be reliable. Moreover, legal regulations prevent manufacturer from using strong lasers for safety purposes and laser spots need to stand out from the natural lightings to be registered by the cameras. The fact that there is only one or few detectors (cameras) and multiples emitters (weapons, scopes, binocular,…) potentially pointing at the same area limits the number of trainees concurrently working in front of a screen. Complex time or spectral band sharing solution must then be used.

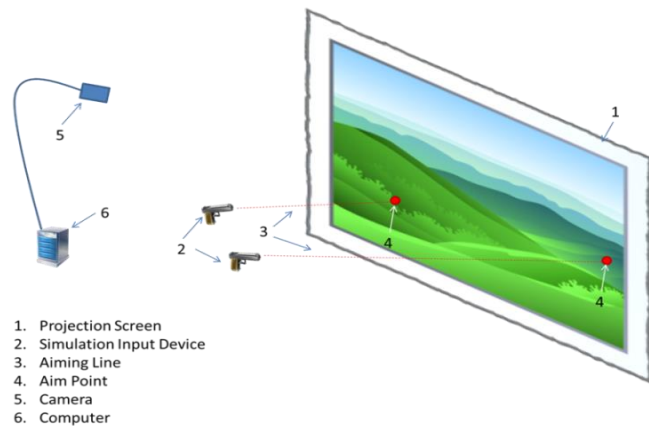


Figure 1: Common laser based virtual weapon training system

OBJECTIVES

The consumer electronic product market has driven dramatic technological advances in the recent years. Smaller and cheaper sensors, computing devices, portable Artificial Intelligence (AI) object recognition and real-time image processing are all boosted by the smartphone market, the Internet of Things and the need for the information industry to process automatically an exponentially growing number of videos and photos.

These advances will benefit the training industry because they bring new capabilities in terms of wearable equipment and lead to a profound transformation of how military and police forces train.

Battlefield digitalization is going on for many years. It is now applicable to marksmen training which enables new use cases or scenarios associated to more precise assessment of the trainees' performance by the instructors and more comprehensive feedback to the trainees. Image analysis, coupled with ballistic calculations can provide a more precise and more general way to compute the effects of a weapon system than lasers can do.

Collective training will also benefit from the solution. There will be no more limitation in the number of players and a better debriefing will be provided using all collected trainees' data (position, behavior, performances...).

Intelligent weapons will assess weapon handling and give the trainees instant feedback, to correct errors as soon as possible and prevent bad habits from forming. AI modules will monitor trainees and reduce the workload of the instructor by providing high-level and safety warning feedback.

Digitalization of training sessions can also lead to smaller infrastructure needs, enabling the end user to train anytime, anywhere. Results of the training sessions can be consolidated in databases to enable a precise follow-up of the trainees' progress.

MAIN TECHNICAL PRINCIPLES:

Following is a description of the system and what we see as the key characteristics for modern Digital Training. The technical and architectural choices hereafter have been made according to different end-user opinions.

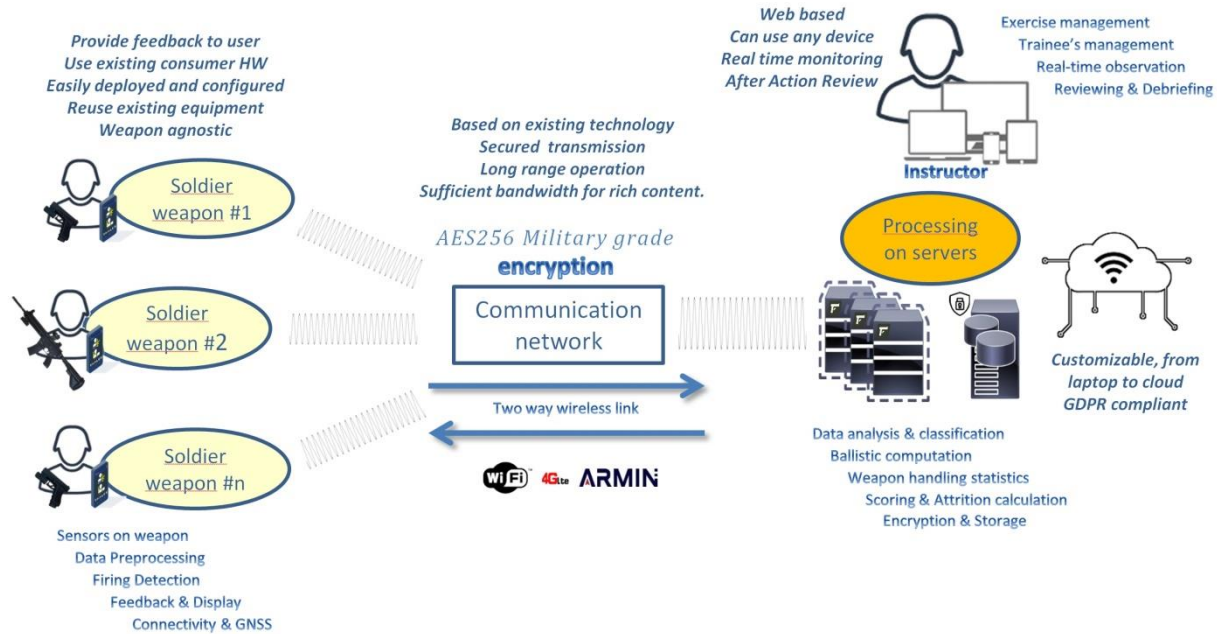


Figure 2: System description

Weapon sensors

While most training systems use dedicated weapon replicas, being able to use simulation input devices or service weapons increases the flexibility of the solution.

The sensor module is attached to a standard picatinny rail and does not require any weapon modification. An inertial measurement unit (IMU) registers the different forces applied to the device, provides information on the weapon handling and also detects gunshots. Module is ruggedized as to be able to function on real weapons and sustain the strong accelerations generated by the recoil. The module also contains one or two cameras with different optical properties selected to comply with the distance of engagement. The cameras continuously register images facing the muzzle of the weapon. Detection capacity, including stationary targets, buildings, vehicles and humans will be discussed later in this document.



Figure 3: Examples of sensors implementation

The sensor module is attached to a standard picatinny rail and does not require any weapon modification. An inertial measurement unit (IMU) registers the different forces applied to the device, provides information on the weapon handling and also detects gunshots. Module is ruggedized as to be able to function on real weapons and sustain the strong accelerations generated by the recoil. The module also contains one or two cameras with different optical properties selected to comply with the distance of engagement. The cameras continuously register images facing the muzzle of the weapon. Detection capacity, including stationary targets, buildings, vehicles and humans will be discussed later in this document.

Smartphone Trainee App

Objective debriefing and feedback is a critical aspect of training and the availability of ruggedized smartphone makes it a logical choice for use as the trainee's interface. Thanks to the consumer market, these platforms combine good communication capability, precise multi constellation Global Navigation Satellite Systems (GNSS) positioning capability, ample processing power, large and clear screens and even AI accelerator in the last generation. The smartphone app is thus both usable as a positioning device, a local preprocessing device for the sensor data and as a trainee interface giving easy access to function such as registering to a larger training exercise, configuration and calibration of the weapon and giving feedback on its current status, marksmanship performance, security warnings. Refer to the First Application section for an example of implementation.

Communication capacity

One of the digital firing objectives is to facilitate collective training with the associated debriefing capabilities. Efficient collective training requires a high performance communication system between trainees and instructors.

Again, the use of smartphones is a relevant choice as it provides various communication solutions and interfaces. Three of them were tested:

- Direct Wi-Fi communication is the easiest thing to do. It provides large bandwidth and low latency. With a 50 to 100 meter operating range, this solution is only usable for a small exercise or in facilities already equipped with a Wireless Distribution System covering the whole training zone.
- Long-Term Evolution (4G LTE) telecommunication network can either be standard operator or private dedicated network. It provides good bandwidth with a larger operational range, from a hundred meters in urban areas to more than ten kilometers in rural areas. A standard operator network cannot be used as such because of obvious security concerns which implies to put in place a strongly encrypted virtual private network (VPN).
- Military radio: Ultra high frequency (UHF) can provide a good solution for infrastructure-less training sites. They often combine long range of operation with high-energy batteries and additional capabilities, such as meshed network. The problem with that type of network is that bandwidth is often not that good (≤ 1 Mbps) and cannot support a large number of connections with acceptable latency.

The THALES ARMIN product was selected because it bridges the worlds of smartphones and Military radios. It was used to provide a military grade encrypted VPN over 4G LTE operator network and seamless interconnection through THALES St@rMille military radio meshed network. Smartphones can either be connected directly to the WIFI network or through other phones or to the LTE network. (ARMIN 2018)

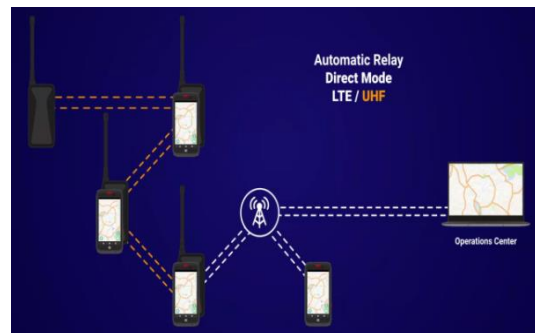


Figure 4: Meshed Military Radio Network & interconnection to 4GLte operator network.

Processing

The processing subsystem can be hosted either locally or remotely on a cloud infrastructure.

It processes the sensor data and performs all application-specific tasks such as ballistic computations, sensor data analysis, attrition calculation, marksmanship analysis and user feedback.

Instructor Interface

The instructor device has to meet two main principles:

- Versatility: a single application allows instructors to perform all their tasks, from exercise creation to runtime monitoring and debrief in an integrated interface.
- Flexibility of use: on any platform, on site or remotely, with any number of instructors and with disconnect-reconnect capacity.

Hence, the instructor's application is a Web application utilizing the web browser of any platform, computer, tablet or smartphone.

The instructor's MMI is configured in accordance with the type of training, individual, collective, basic, advanced... Refer to the First Application section for an example of implementation.

FIRST APPLICATION: A PORTABLE DEBRIEFING STATION FOR LIVE TRAINING

A first prototype was designed and built, with the support of former French Special Forces personnel in terms of training requirements and the following high level user needs were captured:

- System shall be lightweight, transportable and easily deployable
- The solution shall be autonomous, that is to say not dependent on specific instruments or sensors linked to the infrastructure.
- The solution shall not require any weapon modifications, and calibration must be quick.
- All events shall be recorded for analysis and replay, database shall be interoperable and extensible

- Debriefing tools shall be provided for :
 - o Individual performance assessment (e.g. accuracy, speed, marksmanship...)
 - o Collective assessment (communication, decision making...)
 - o Posture and placement analysis of the individual team members during the action

Prototypes were demonstrated at IITSEC 2018 & 2019 and to French and German Tactical Teams. Feedback so far indicates that the solution that was meant for Tactical Teams and Special Forces training, can also be used to train first responders (Police forces).

Web based user Interface

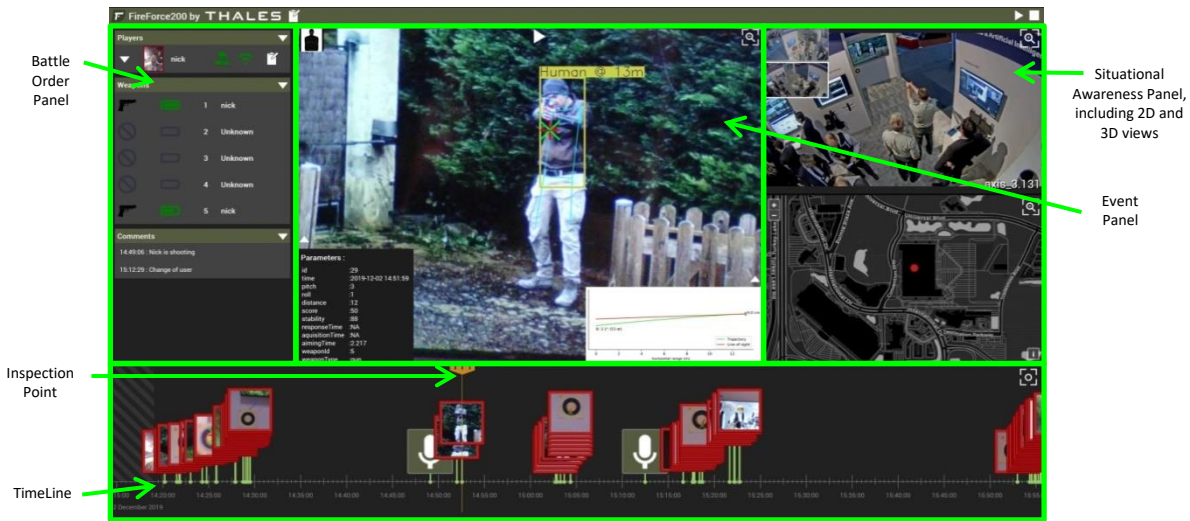


Figure 5: Web based user interface

Actions can be followed during a training session using a web interface. The same interface can also reload a previous session to provide After-Action-Review. The interface can be opened in multiple tabs, inspecting different panels or different moments in time.

The main interface (figure 5) is divided into panels that can be resized and zoomed in:

- At the bottom sits a timeline that logs all the gunshots and events issued by the instructor. An “inspection point” can be dragged on the timeline to inspect the situation at a given point in time. All additional panels then display the situation at the time of the inspection point.
- On the right, a 2D cartographic view with trainees’ positions and tracks is complemented with an optional video-feed panel from a surveillance camera system and provides a situational awareness of the action.
- On the left, the order-of-battle panel gives information about engaged trainees, weapons status and instructor issued comment and events.
- In the middle, the event panel displays information about the last event/shot: pictures, short video feed as viewed by the gun, marksmanship statistic, ballistic information and score card.



Figure 6: Trainees contextual menus open exercise-wide score cards

Trainee interface

Trainees carry a smartphone providing GNSS positioning, sensor data preprocessing and user interface.

The trainee User Interface contains multiple pages (figure 7) that permit a user to:

- Register the user to a session by providing a “mugshot”, a name, an affiliation and binding one or more weapons to the user by scanning a Quick Response code (QR-code) present on the sensor module.
- Calibrate the weapon modules within seconds by precise registering of the aimed point.
- Receive feedback on the previous shots, with pictures and marksmanship analysis data.

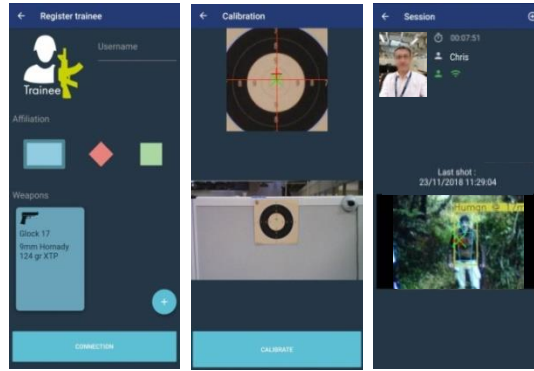


Figure 7: Trainee UI pages

Camera Optical calibration

The cameras must be calibrated to obtain intrinsic parameters and in the case of a multi camera system, extrinsic parameters. Such calibrations are crucial as they will affect the angular precision of the system and thus the ability to use it for long-range shooting. Table 1 presents pixel and angular precision for various sensors and lenses used in the experiments.

Table 1: Calibration Result for various tested camera for Full-HD resolution

	Horizontal FOV	Re-projection error (precision)	
Sony IMX219 1/4" sensor, Focal length = 3 mm	36.7° (0.64 rad)	0.58 pixel	0.19 mrad
Sony IMX219 1/4" sensor, Focal length = 6 mm	19.9° (0.34 rad)	1.22 pixel	0.21 mrad
Sony IMX219 1/4" sensor, Focal length = 25 mm	4.7° (0.08 rad)	1.18 pixel	0.05 mrad
OnSemi AR0330 1/3"sensor, Focal Length = 6mm	40.3° (0.70 rad)	0.81 pixel	0.29 mrad
OnSemi AR0330 1/3"sensor, Focal Length = 16mm	14.4° (0.25 rad)	1.17 pixel	0.15 mrad
OmniVision OV2735 1/3"sensor, Focal Length = 25mm	15.2° (0.26 rad)	0.27 pixel	0.03 mrad

Note that FOV is not only dependent on the focal length but also on sensor size.

Intrinsic Parameters are constituted by the parameters that are internal and fixed to a particular camera/lens. Given those intrinsic parameters, the system is able to compute the relation between a 3D vector in the camera coordinate frame (X,Y,Z) and 2D coordinates in the image plane (U,V). We use the academic extended pinhole model consisting of the projection matrix (fx, fy, cx, cy) and lens distortion parameters (k1, k2, p1, p2). Our focal lengths are relatively long and distortion is minimal.

Note: Our solution uses standard factory chessboard camera calibration process and model. (Devernay & Faugeras, 2001)

$$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} X/Z \\ Y/Z \end{bmatrix}$$

$$\rho = x^2 + y^2$$

$$\phi = k_1\rho + k_2\rho^2$$

$$\begin{bmatrix} dx \\ dy \end{bmatrix} = \begin{bmatrix} x\phi + 2p_1xy + p_2(\rho + 2x^2) \\ y\phi + 2p_2xy + p_1(\rho + 2y^2) \end{bmatrix}$$

$$\begin{bmatrix} U \\ V \end{bmatrix} = \begin{bmatrix} fx & 0 & cx \\ 0 & fy & cy \end{bmatrix} \begin{bmatrix} x - dx \\ y - dy \\ 1 \end{bmatrix}$$

Figure 8: From 3D to 2D coordinates using the pinhole camera model

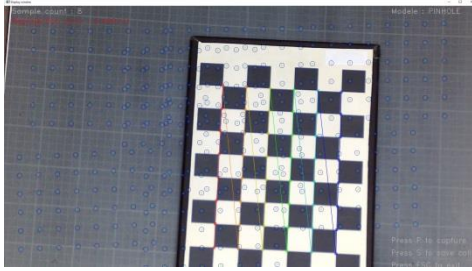


Figure 9: Camera calibration interface

Extrinsic parameters just consist of the rigid transform between each camera and will not be detailed here.

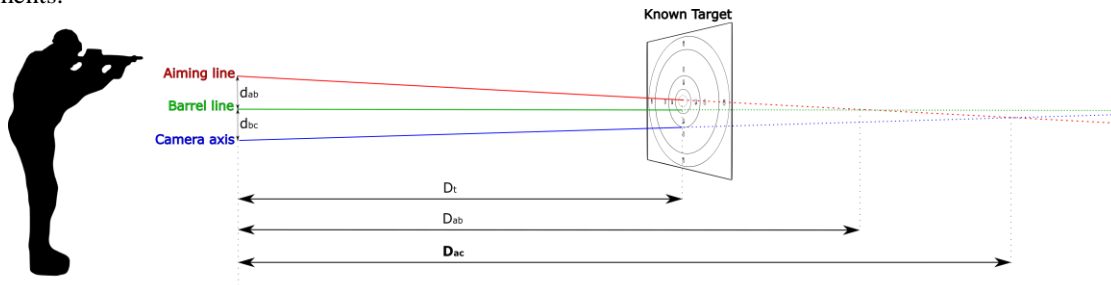
Our calibration toolchain was able to obtain subpixel accuracy for a range of cameras and further experimentation proves that factory calibration per optical solution provides enough precision for distance stadimetry and precise firing if manufacturing tolerances remains reasonable. This calibration phase will thus not affect the end user.

Weapon ↔ Module calibration

To provide correct operation, relative position and orientation between the cameras, the barrel and the aiming device must be calibrated. As the camera is an angular sensor, no time consuming mechanical calibration is needed, calibration is done purely in software.

Calibration between the barrel and the aiming device is routinely done by the soldier and will not be discussed here. The system just takes as a parameter the vertical distance between the sight and the barrel and the boresight distance used by the user when sight calibration was done.

Calibration between the sight and the camera is done in a very straight forward way. The user aims at a known target then registers an image. The user then selects the aimed point on the image displayed on his smartphone and the system uses this point, together with a distance computation to compute the alignment of the camera relative to the sight and the barrel. The whole operation takes only a few seconds and the user can verify that the calibration is OK by aiming at another point, at another distance. Note that this calculus is done both for the horizontal and vertical alignments.



d_{ab} is the vertical distance between the aiming device and the gun barrel.
 d_{bc} is the vertical distance between the gun barrel device and the camera axis.
 D_t is the distance to the target. It can be computed knowing the metric size of the target and the pixel size as seen by the camera.
 D_{ab} is the distance where the aiming line crosses the barrel axis. This is known as the boresight distance.
 D_{ac} is the distance where the aiming line crosses the camera axis.

Knowing D_{ac} is enough to have a calibrated system and correctly re-project the aiming point in the images for any firing at any distance (bullet impact will be calculated later by ballistic simulation)

Figure 10: Calibration principle

Distance estimation

We need a distance to carry out the necessary ballistic calculations. Although we first considered using a laser range finder, we decided to use the existing sensors (e.g cameras) only to keep the advantage of being a fully passive sensor. The chosen method is thus stadimetric range finding.

The stadimetric algorithm makes various measurements on known objects (targets or humans) detected on the image. It then uses its reference values database (Figure 11) to calculate distance using the camera parameters.



Figure 11: Stadimetric database

Measurements on adult humans work best on persons close to the standards. The reference size was chosen using 50th percentile found in anthropometry literature so to maximize the validity of result. Typical deviation is below 10% for 90% of the adult population, male and female. (NASA-STD-3000 1994)

Measurements on known rigid targets are computed with subpixel accuracy and precision is only limited by the precision of the camera calibration. (See Table 1 and figure 12 for results on circular targets)

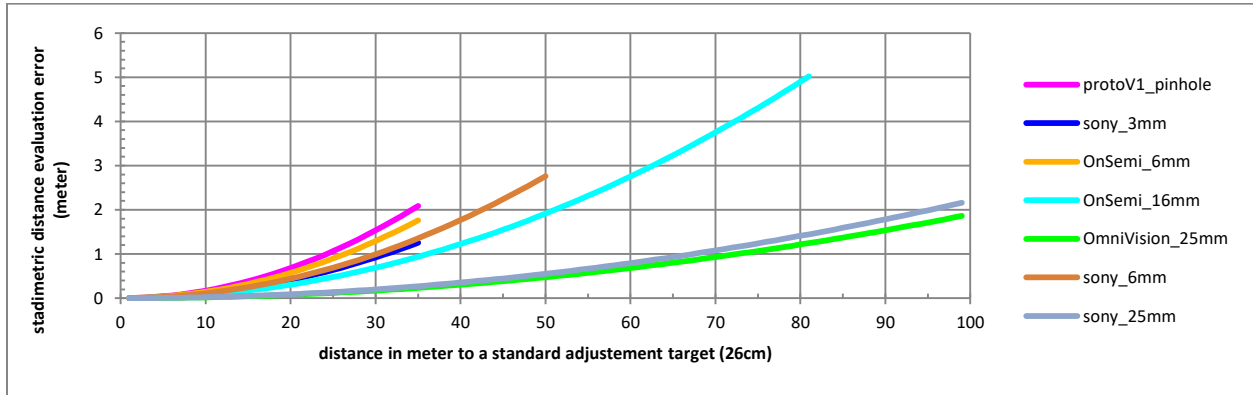


Figure 12: Distance measurement Error due to camera calibration.

Ballistic calculation

The computation of the impact point is based on an algorithm that has been used in Thales simulators for more than 10 years. It does not simulate internal ballistics (inside the weapon bore) nor intermediate ballistics (at the muzzle). (Nennstiel 1999)

It uses a fire table for each ammunition type, for example 9 mm Hornady 124 XTP, 9 mm MagTech FMJ or 223 mm Federal 55 FMJ. We can get the firing tables from ammunition original equipment manufacturer (OEM), from field measurements or by default from freely available resources on the internet.

The following parameters are taken into account:

- weapon muzzle position, orientation, speed and angular velocity (given by IMU)
- ammunition temperature (default to 20 °C)
- ambient temperature (default to 20 °C)
- altitude (default to 0 m)
- pressure at sea level (default to 1013,25 hPa)
- cross wind (default to 0 m/s)

Actual restriction of the algorithm:

- Coriolis effect is not taken into account as it was deemed irrelevant for direct fire.
- For simplification, some parameters (like gyroscopic effects) that should be linked to the weapon are included in the ammunition fire table. A better way could be to take into account the weapon barrel length and compute the initial ammo speed. Barrel rifling orientation (right or left) and twist rate would also be used to adjust gyroscopic effect.

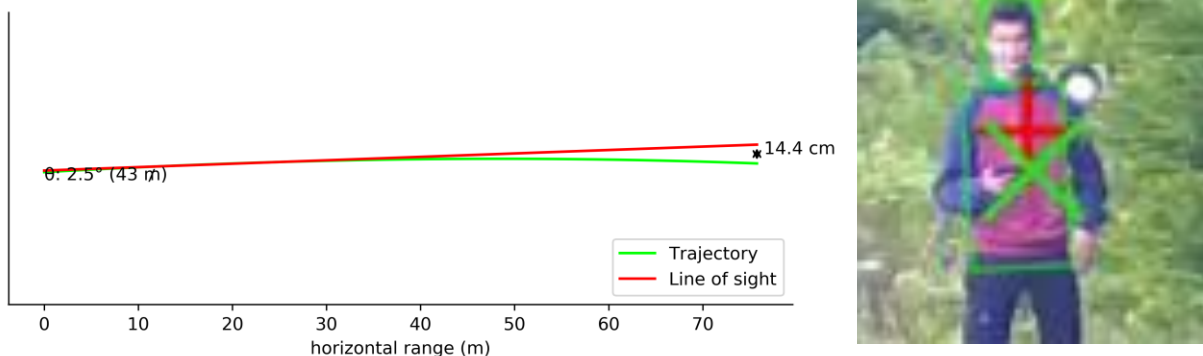


Figure 13: Ballistic as reported by the tool for a shot on a human at 75m (180 pixels height)

On figure 13, we can see two crosses on the image: the red one indicates the aimed point and the green one indicates the impact point on the target. On the graph, we can see that for 9 mm Hornady 124 XTP ammunition, 2.5° barrel pitch), bullet drop at around 80m is 14.4 cm. This kind of information is presented to the trainee and instructor and can be used to improve marksmanship and provide a baseline for ballistic effects understanding.

We used freely available internet resources to validate impact point computation: This was done using the ballistic calculator from JBM Ballistics, LLC (https://www.jbmballistics.com/cgi-bin/jbmtraj_drift-5.1.cgi). Precision could also be adjusted by modifying the ammunition fire table to match a particular user specification.

Inertial measurement

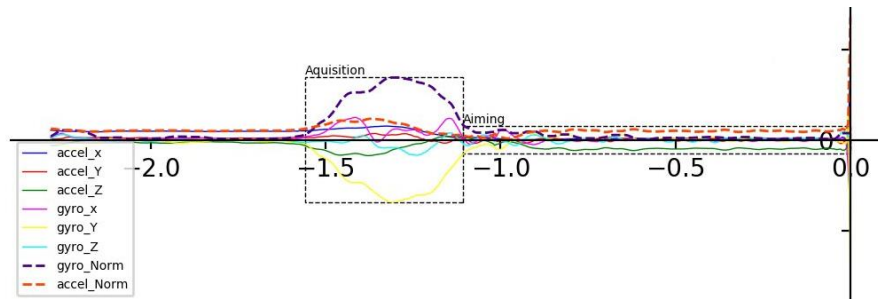


Figure 14: IMU sensor readings during the 2.5 seconds before a shot.

A complete 6axis IMU (3axis accelerometer + 3 axis gyroscope) is used to gather inertial and gyroscopic data from the gun. Those data can be used to measure the time to go from a rest position to an aiming position (acquisition time) and the stabilization before the actual shot (aiming time). The jitter during the aiming phase also gives interesting feedback about the trainee's aiming stability and can help uncover firing position problem.

The IMU data is also fed into a firing detection algorithm that compares the IMU readings to a recoil database to detect the actual firing. This part still needs improving to get rid of false-positive detections (drop onto hard surface, severe shocks...) and additional studies are planned to try to alleviate this problem.

Detection capacity, and robustness

Recent advance in object recognition allows the detection of objects quickly and with unprecedented robustness against noise, illumination or viewpoint changes. Neural Network based object recognition runs now at real-time rates (> 30 Hz) on commodity notebook and desktop PC as long as they are equipped with a capable GPU.

Thanks to high demand from consumer market to embed AI systems in handheld and IoT device, small and large companies like Canaan, Sony or Qualcomm already propose neural network accelerators on their smartphones, IoT SoCs or even inside their camera sensor. These chipsets will permit in the near future to run detection on smartphone or even directly into the weapon.

We have done our academic homework and looked at Joseph Redmon and Ali Farhadi YoloV3 object detector, at Carnegie Mellon University OpenPose and Google MobileNet. Please refer to these papers for detail on robustness to noise and illumination changes. (Howard et al., 2017; Redmon & Farhadi, 2018; Cao, Zhe, et al., 2018). Finally, we decided to implement our solution.

Human skeleton detector is quite robust even in presence of camouflage, partial occultation and multiple persons in the image (Figure 15). It can be used to compute very precise attrition (head shot, chest shot, limb shot ...) and marksmanship score cards.



Figure 15: Detection example at different resolution (distance) and with various pose, occultation and camouflage.

We mainly use the object detector to register shooting targets and compute score cards (figure 16) but it can also be used to detect common objects like cars, animals, chairs, doors or specific scenario defined content such as buildings and vehicles and trigger special event like sound or smoke effects.



Figure 16: Target and human detection is used to aggregate shots in score cards and assess marksmanship.

Based on our experimentation, these detectors provide accurate and usable detection when the detected target is bigger than 30 pixels. Standing human skeleton is detected reliably when measuring more than 70 pixels. Figure 18 presents pixel size of a human and a shooting target as seen at various distance by different Full-HD sensors, it shows that detection distance is closely linked to the sensor type and focal length. These in house calculations were validated by field experiments.

An aiming precision model was created and successfully validated with field experiments. The model varies linearly with the distance and is also strongly influenced by the quality of the sensor and lens. Using the right combination of lenses and sensors for the needed operating distance permits to achieve sub centimeter precision, even for long range firing (Figure 17).

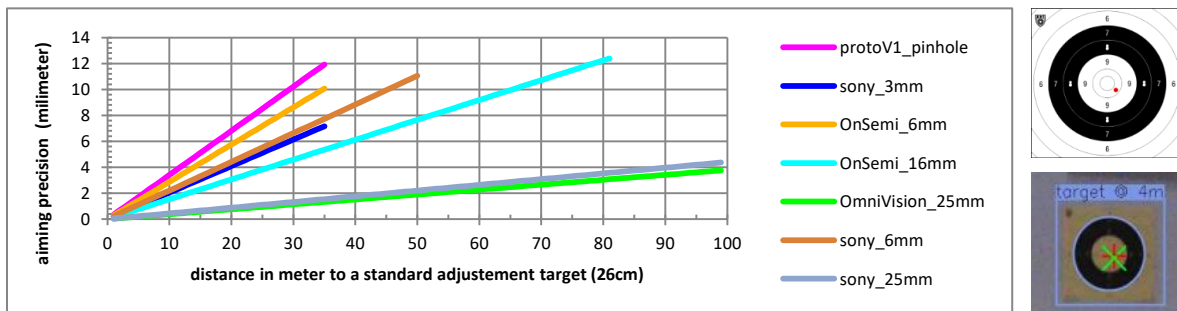


Figure 17: Aiming precision

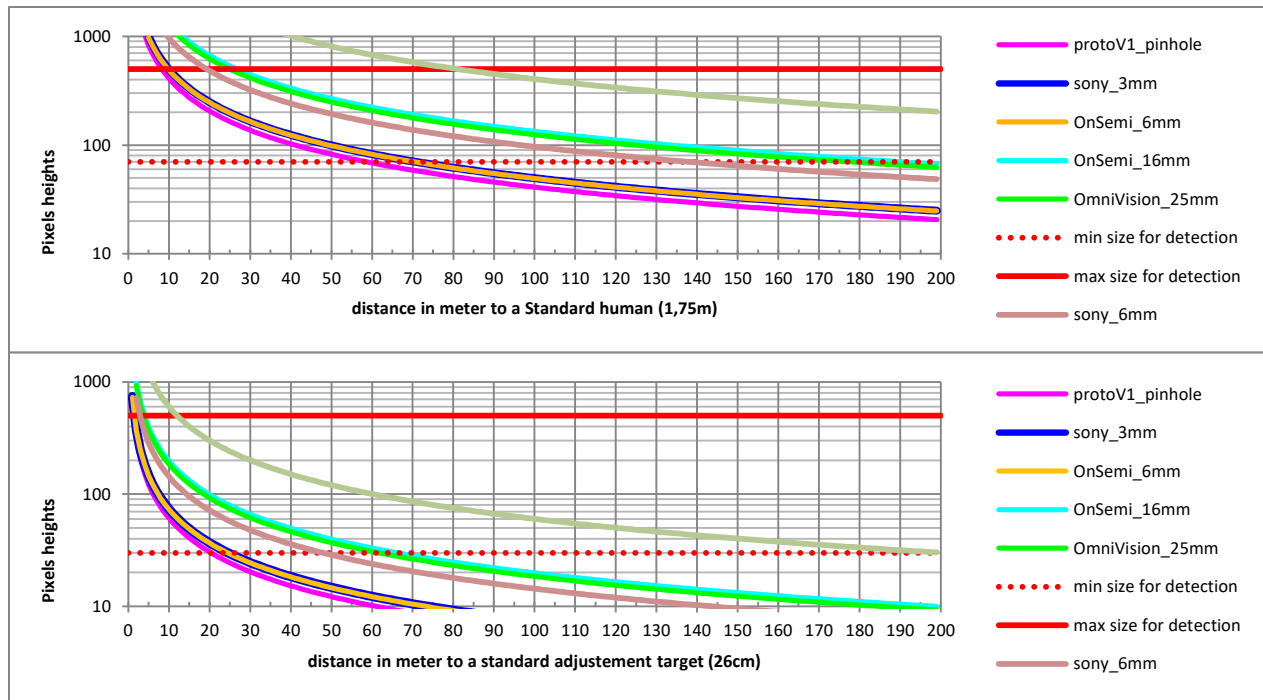


Figure 18: Theoretical calculation: sensors & lenses VS distance of detection

NEXT STEPS AN CONCLUSION: TOWARD A FULL REPLACEMENT OF THE LASER SYSTEM

Some points need to be addressed to broaden the usability of such a system. The digital firing principle relies heavily on imaging sensors and their performances. To be able to use it in a night scenario, tests must be performed with more sensitive cameras, night-vision device (NVD) or even thermal imaging devices. Humans and object detectors already work with black and white near infrared and thermal image but mounting such devices on a handgun will need additional research.

The system requires high-resolution images and low latency network to meet the operational requirements. As the image average size and number of connected stations will increase, the present architecture will need to move towards a more distributed one, based on local Image analysis and AI processing to decrease the necessary bandwidth and reduce central computing needs. Decentralized processing and AI calculation on the edge will be investigated to convert large images to small semantic data at the trainee level, inside the weapon module or inside the trainee's smartphone to minimize data transmission.

Computing and visualization technologies have made huge progresses thanks to consumer mass market. Benefiting from it, new training solutions can now be designed and developed, changing the way of overcoming current limitations of traditional systems.

This R&D work shows that the use of COTS cameras instead of lasers offers new capabilities in terms of target occultation and identification. Indeed, cameras bring a lot of information which can be processed providing useful added value to the instructor and his trainees.

For the force-on-force use case, research will have to be done, to provide reliable target identification, shots through obstacles assessment and more robust long range firing (e.g. RPG firing to buildings or aircrafts)..

In three to five years from now, such a system may completely replace laser-based marksmanship and cooperative trainers, thanks to more performant cameras (e.g. night operations) and local computing. The system architecture will move towards an "Internet of Things" (IoT) based one to address computing and network issues when many devices are interconnected. Then digital firing will continue to naturally benefit from COTS technology progress.

GLOSSARY

Acronym	Meaning
GDPR	The General Data Protection Regulation is a regulation in EU law on data protection and privacy in the European Union (EU) and the European Economic Area (EEA).
AES256	The Advanced Encryption Standard is a specification for the encryption of electronic data established by the U.S. National Institute of Standards and Technology (NIST) in 2001. AES256 use a 256 bits key size and is considered very strong encryption.
Picatinny rail	Also known as the MIL-STD-1913 rail, this is a military standard rail interface system that provides a mounting platform for firearm accessories. Most modern rifle and hand gun are equipped with it.
GNSS	Global Navigation Satellite Systems. Four GNSS constellation are available today: GPS, Glonass, Galileo and BeiDou. A combined usage of these constellations can result in better performance compared to a single system.
VPN	A Virtual Private Network extends a private network across a public network as if the computing devices were directly connected to a private network. VPNs are often associated with encryption technique to prevent disclosure of private information.
Stadimetric	Stadimetric rangefinder evaluates a distance by comparing an object of known size with a scale contained in an optical instrument.
Neural Network	A neural network is a network or circuit of neurons, or in a modern sense, an artificial neural network, composed of artificial neurons or nodes. These artificial networks may be used for predictive modeling and are very good at modeling vision tasks like object recognition.
GPU	A graphics processing unit (GPU) is a specialized electronic circuit designed to rapidly manipulate and alter memory to accelerate the creation of computer graphics. Their highly parallel structure makes them more efficient than general-purpose central processing units for algorithms that process large blocks of data in parallel like neural network for example.
IoT	The Internet of things (IoT) is a system of interconnected devices able to communicate with each other and server applications through the internet network. It is implemented in vending machines, industrial equipments, electric meter, refrigerator...
SoC	System on a chip is an integrated circuit (also known as a "chip") that integrates all or most components of a computer.
NVD	night-vision device (NVD) is an optoelectronic device that allows images to be produced in levels of light approaching total darkness.

Definitions based on <https://www.wikipedia.org/>

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