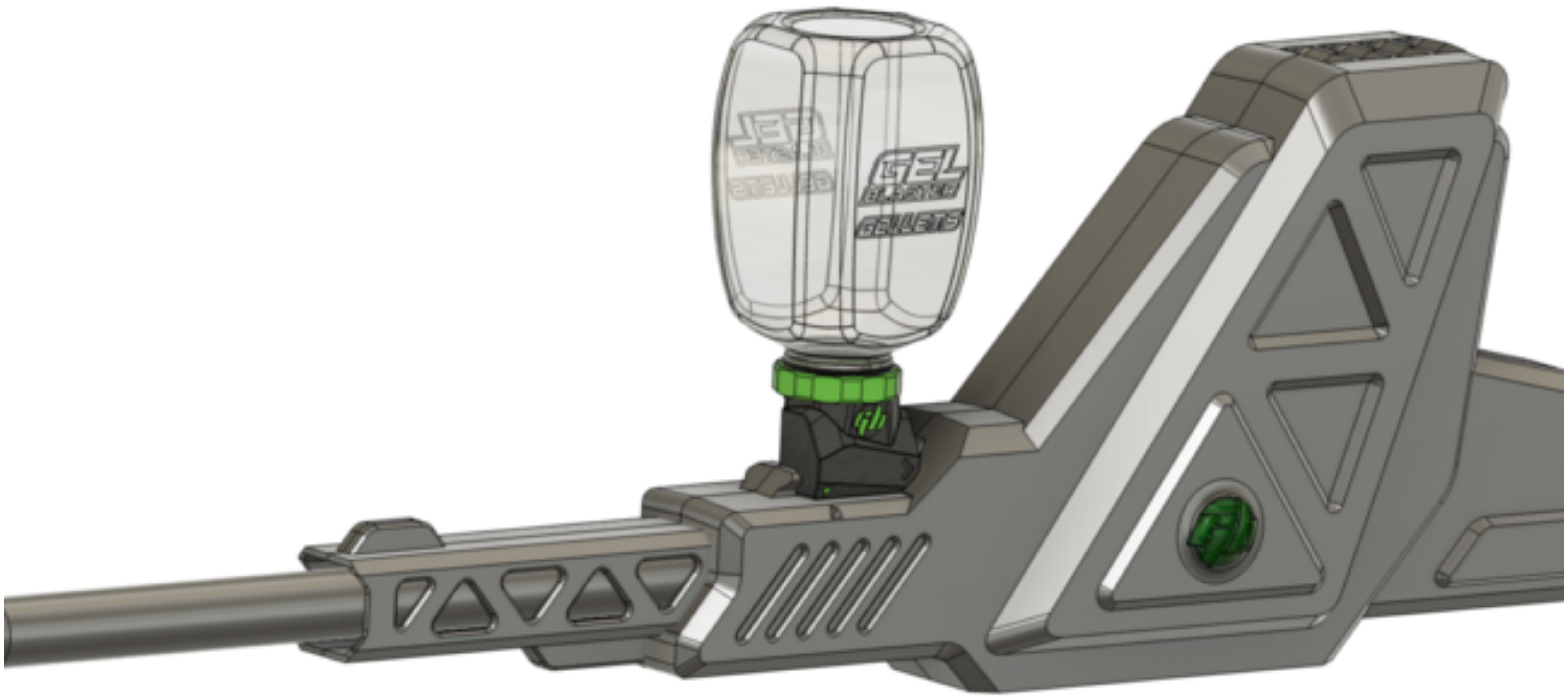
“Wingman” AI GelBlaster Surge based turret incubation proposal

GO PLAY!



Wingman?

NVIDIA JETSON POWERED, ARTIFICIAL INTELLIGENCE ENABLED ROBOTIC OPPONENT

Guinn Partners 2018 State of The Drone Industry report

The vision

As a long time Guinn Partners adjacent resource formally going back to Rocket-Squad days, informally to 3DR Texas timeframe, I'd like to request incubation assistance for a robotic GelBlaster based turret project currently known a "Wingman". Given the specialization in emerging technology, enabling technologies, drones, mobility, & outdoor sporting goods this project is perfectly positioned to help further demonstrate all of the things Guinn Partners is already known for being best in class at. Potential outputs of this project incubation include:

GelBlasters STEM SDK educational kit for learning industry standard AI models

- Competition robotics
- GelBlasters game product payload to tie into future smart sensor product line
- Pre loaded GelBlaster proprietary AI targeting / game play / scoring logic code
- Virtual Opponent for GelBlasters events! Stick on wall, put on tripod, mount to ceiling!
- No friends with you? Face off against a robotic opponent!
- "Go Play" by yourself, prop up the turret, and virtual target, hone your skills.
- Rank amongst peer players attempting to defeat the turret in their own environments!
- Score accurately against the e-target, and collect e-badges, and achievements.

Proprietary ROS1 & ROS2 logic blocks for reuse in commercial consulting / incubation

- Reusable logic is created at each step of research & development
- Think 'Cable Cam' reimplemented in ROS, available to *all* ROS enabled platforms.
  - ✦ Add auto targeting to any existing payload on a gimbal as long as it has a camera
  - ✦ Example: Robot quadruped dog, with a camera platform on its back doing scripted cinematic sequences that include aiming a camera at a "target" aka "POI" for a shot.

WHERE HAVE WE BEEN? WHERE DO WE WANT TO GO!?

Rapid Prototyping for the win

We've been grinding, and hustling, while pushing to our Git repo along the way as we go. Our quest has brought us down many paths, all involving our incremental learning.

Making an AI enabled turret is a non-trivial task, and is in fact quite daunting when you dive into the minute technical details involved. We've got a backlog of ideas, and tasks on a card wall, and we've been slowly working through them. At each step we must familiarize ourself with new technologies, their nuances, and ways to work around small hurdles. Every step requires poise, and focus, as well as a stream of resources to enable our team to succeed. Raw passion has been our primary fuel, alongside the desire to both learn, and teach.

Unfortunately passion doesn't pay for the expensive sensors, or compute platforms we need to keep our momentum. This is where Guinn

Step 1.5 turret version in John Cherbini's lab

Partners comes in, simply put the Wingman project needs your incubation, and we are asking for it in the form of a "match" on our R&D costs moving forward. Below is a table showing the existing project expenditures. Matching our investment input would allow us to both expand our team, and the pace at which we are able to develop capabilities subsequently resulting in proprietary knowledge and code that Guinn Partners can reuse in the near future.

Item	Quantity	Cost	Purpose
Time tracking across all prototype phases			
2-3 hours average input per day Mon-Fri. [John Cherbini & Kevin Finisterre]	6 months x 2 men	<waived>	Write code!
4+ hours average input per day Sat-Sun. [John Cherbini & Kevin Finisterre]	3 months x 2 men	<waived>	Write code!

The current project phases derive their naming convention from Sega's Arcade division that was historically responsible for the "Model 3"platform used in the late 90's. Our phases have been named "Step 1", "Step 1.5", and "Step 2" accordingly.

```
Sega Model 3
PowerPC 603e + tilemaps + Real3D 1000 + 68000 + 2x SCSP
Preliminary driver by Andrew Gardner, R. Belmont and Ville Linde

Hardware info from Team Supermodel: Bart Trzynadlowski, Ville Linde, and Stefano Teso

Hardware revisions
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Step 1.0: 66 MHz PPC
Step 1.5: 100 MHz PPC, faster 3D engine
Step 2.0: 166 MHz PPC, even faster 3D engine
Step 2.1: 166 MHz PPC, same 3D engine as 2.0, differences unknown
```
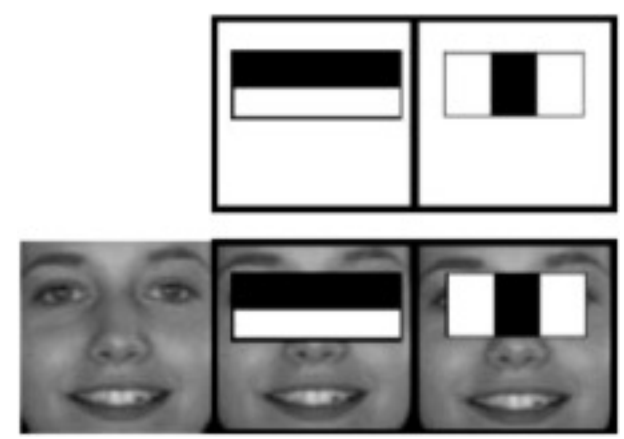
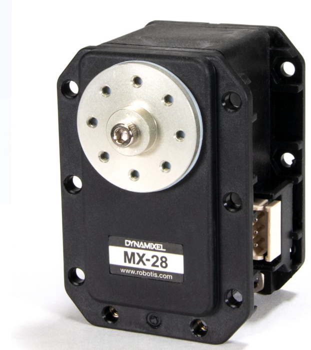

Step 1 for us represented the initial phase of converting ideation into reality. All logic at this level was ad-hoc absorbed from existing "I made my nerf gun shoot me in the face" style projects that had been making the viral rounds on social media. Raspberry Pi4 was fairly new at this time, and we used this project as an excuse to explore the Raspi4 landscape. OpenCV + Haar Cascade was the root of logic at this phase. We used both stepper motors, and Dynamixel variants for initial proof of concept. Camera choices had not yet been standardized so we were using RasPI HD camera, and a Logitech webcam for the first prototypes.

OpenCV





Item	Quantity	Unit Cost	Purpose
Step 1 Prototype phase			**Proof of Concept**
Raspi4 https://www.raspberrypi.com/products/raspberry-pi-4-model-b/	1	$44.99	Compute Platform tests
Raspi4 High Quality Camera https://www.raspberrypi.com/products/raspberry-pi-high-quality-camera/	2	$49.99	Vision System tests
6mm wide lens https://www.adafruit.com/product/4563	1	$24.99	Vision System tests
16mm telephoto lens https://www.adafruit.com/product/4562	1	$49.99	Vision System tests
SanDisk 512G https://www.westerndigital.com/products/memory-cards/sandisk-extreme-pro-uhs-i-microsd#SDSQXCD-512G-GN6MA	2	$139.99	Compute Platform tests
Toby Tripod https://joby.com/ca-en/compact-advanced-tripod-for-smartphone-and-camera-jb01763-bww/	1	$119.99	Supporting hardware
Volessence 5000 battery https://www.amazon.com/Volessence-50000mAh-Laptop-Portable-Charger/dp/B07RNZZXRM	1	$125	Supporting hardware
MX-28T servos https://www.robotis.us/dynamixel-mx-28at/	4	$289	Motion Control
U2D2 Power Hub Board Set https://www.robotis.us/u2d2-power-hub-board-set/	2	$18.99	Motion Control
U2D2 https://www.robotis.us/u2d2/	2	$32.99	Motion Control
Dynamixel brackets https://www.robotis.us/fr07-s101-set/	4	$14.99	Motion Control
drv8825 Stepper Driver & Stepper motors	2	$14.99	Motion Control
Adafruit Huzzah32	2	$19.99	Fire Control system
Adafruit Non-Latching Relay Mini https://www.adafruit.com/product/2895	6	$7.99	Fire Control system
ESP32 Thing+ https://www.sparkfun.com/products/20168	4	$24.99	Fire Control system
Realsense D455 https://store.intelrealsense.com/buy-intel-realsense-depth-camera-d455.html	2	$419.99	Vision System tests
Realsense D435i https://store.intelrealsense.com/buy-intel-realsense-depth-camera-d435i.html	2	$345	Vision System tests
2-way all in one single servo Dynamixel https://www.robotis.us/dynamixel-xl430-w250-t/	1	$49.99	Motion Control
Gelblasters Surge XL https://gelblaster.com/products/surge-xl	5	$89.99	Fire Control system
Inland 1.75 mm ABS https://www.microcenter.com/product/485643/inland-175mm-black-abs-3d-printer-filament-1kg-spool-(22-lbs)	2	$16.99	Supporting hardware

Raspberry Pi 4 is cheap, but for us it just doesn't perform!

	Acc (%)			Time(sec)			Memory (GB)			CPU(Power/W)			GPU(Power/W)		
Dataset	TX2	Nano	PI	TX2	Nano	PI	TX2	Nano	PI	TX2	Nano	PI	TX2	Nano	PI
Idle	-	-	-	-	-	-	1,9	1,5	1,4	0,675	0,47	0,30	2,6	0,76	-
5K	87,6	87,5	87,2	23	32	173	2,6	2,0	2,1	2,23	1,50	3,5	5,27	2,23	-
10K	93,8	93,9	91,6	32	58	372	3,1	2,75	2,6	2,78	2,32	3,6	5,32	3,25	-
20K	94,6	94,5	-	52	-	462	4,5	ERR	4,0	3,76	-	3,9	5,22	-	-
30K	96,4	-	-	122	-	-	5,2	ERR	ERR	4,25	-	-	5,74	-	-
45K	97,8	-	-	235	-	-	6,5	ERR	ERR	4,92	-	-	6,29	-	-

	Raspb. PI 4	Jetson Nano	Jetson TX2
Performance	13.5 GFLOPS	472 GFLOPS	1.3 TFLOPS
CPU	Quad-core ARM Cortex-A72 64-bit @ 1.5 GHz	Quad-Core ARM Cortex-A57 64-bit @ 1.42 GHz	Quad-Core ARM Cortex-A57 @ 2GHz + Dual-Core NVIDIA Denver2 @ 2GHz
GPU	Broadcom Video Core VI (32-bit)	NVIDIA Maxwell w/ 128 CUDA cores @ 921 MHz	NVIDIA Pascal 256 CUDA cores @ 1300MHz
Memory	8 GB LPDDR4	4 GB LPDDR4 @ 1600MHz, 25.6 GB/s	8GB 128-bit LPDDR4 @ 1866Mhz, 59.7 GB/s
Networking	Gigabit Ethernet / Wi-Fi 802.11ac	Gigabit Ethernet / M.2 Key E	Gigabit Ethernet, 802.11ac WLAN
Display	2x micro-HDMI *(up to 4Kp60)*	HDMI 2.0 and eDP 1.4	2x DSI, 2x DP 1.2 / HDMI 2.0 / eDP 1.4
USB	2x USB 3.0, 2x USB 2.0	4x USB 3.0, USB 2.0 Micro-B	USB 3.0 + USB 2.0
Other	40-pin GPIO	40-pin GPIO	40-pin GPIO
Video Encode	H264(1080p30)	H.264/H.265 (4Kp30)	H.264/H.265(4Kp60)
Video Decode	H.265(4Kp60),H.264(1080p60)	H.264/H.265 (4Kp60, 2x 4Kp30)	H.264/H.265 (4Kp60)
Camera	MIPI CSI port	MIPI CSI port	MIPI CSI port
Storage	Micro-SD	16 GB eMMC	32GB eMMC
Power under load	2.56W-7.30W	5W-10W	7.5W-15W
Price	$35	$89	$399

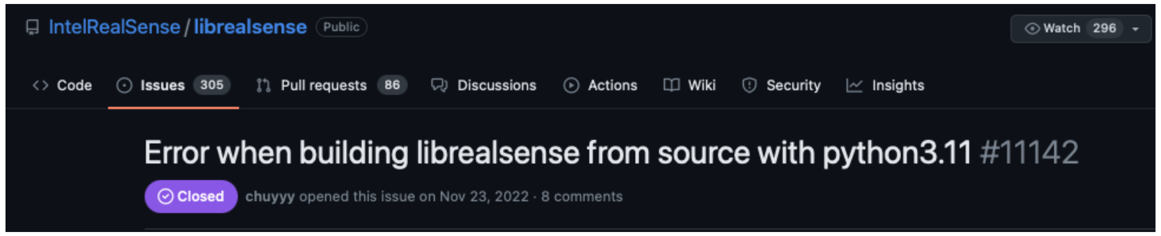
The paper Benchmark Analysis of Jetson TX2, Jetson Nano and Raspberry PI using Deep-CNN pretty well frames the entire learning process for us in Step 1, ultimately coming to the same conclusion that: "Although Raspberry PI without NVIDIA GPU support is the most cost-effective hardware, it is not the right prefer for deep learning applications".

Secondarily at this phase we started learning how poor the default OpenCV Haar Cascade face detection performs at scale. It is great for objects that are up close, and novelty *face tracking* applications, but it just flat out can't handle outdoor, multi target, noisy environments in the context we need it. We saw an enormous amount of false positives with this method, so we moved on from it rapidly.

Step 1.5 came with the realization that all the viral videos were rooted in the same limitations. One being frame rate of RasPi platform, and the second being a lack of GPU. We took a cue from both robotic quadruped vendors, and academia by deciding to go with Intel Realsense cameras, and Nvidia Jetson Nano hardware for the compute package. From there we went on to getting YOLO v7, and "pose" algorithms working with CUDA. Pytorch & Pyvision, and TRT based code took the primary focus. We also looked for a cheaper alternative to Dynamixel brand, and landed on HiWonder serial bus servos as a potential option.

Item	Quantity	Cost	Purpose
Step 1.5 Prototype phase			**Refined Control**
Hiwonder LX-225 Serial Bus Servo/25KG High Torque/Data FeeDback https://www.hiwonder.com/products/hiwonder-lx-225-serial-bus-servo-25kg-high-torque-data-feedback	2	$17.99	Motion Control
Hiwonder brackets https://www.amazon.com/dp/B07PQ12TXS	2	$12.99	Motion Control
Hiwonder Serial Bus Servo Controller Communication Tester https://www.hiwonder.com/products/serial-bus-servo-controller	4	$39.99	Motion Control
Hiwonder HTD-45H High Voltage Serial Bus Servo 45KG Torque with Three Connectors and Data Feedback https://www.hiwonder.com/products/hiwonder-htd-45h-high-voltage-serial-bus-servo-45kg-torque-with-three-connectors-and-data-feedback	2	$24.99	Motion Control
Jetson Relay boards https://www.amazon.com/dp/B08SCPQJZ6	3	$24.99	Fire Control system
Replacement IO-board-B https://www.amazon.com/dp/B0B7ZXDLL6	1	$99.99	Compute Platform tests
Jetson Nano https://www.amazon.com/Yahboom-Jetson-Nano-4GB-Board/dp/B09T37PPRF	2	$239	Compute Platform tests
Jetson Tx2 NX https://www.amazon.com/Yahboom-Jetson-Development-N-VIDIA-Performance/dp/B09Y53TWQJ	1	$519	Compute Platform tests
Xavier NX https://category.yahboom.net/products/nx-sub	2	$899	Compute Platform tests
Xavier AGX https://www.amazon.com/NVIDIA-Jetson-Xavier-Developer-32GB/dp/B083ZL3X5B	2	$1860	Compute Platform tests
NVME storage https://www.amazon.com/Transcend-TS128GMTE110S-128GB-Solid-State/dp/B07CXC32T2	3	$24.99	Compute Platform tests

Intel RealSense is dying a slow death… YOLO rocks!



Using YOLO based models brought amazing differences in our ability to detect targets, and ultimately classify them as what we wanted as opposed to simply looking for every face without additional modifiers in confidence. At the very least YOLO helped us determine that Haar Cascades were not the route we wanted to be taking right now.

In the process we also learned that Intel RealSense cameras can be a pain to integrate into the Jetson workflow for a number of reasons. Likewise we found out that Intel is more or less sunsetting the product line. It will remain a staple of the environment we are attempting to play in, but it will soon enough be considered legacy. This is a solid point to begin investigating alternative camera packages before we marry ourselves further to the Intel RealSense product line, and a failing support system infrastructure.

Intel Says It's 'Winding Down' RealSense Camera Business

BY DYLAN MARTIN ▸
AUGUST 17, 2021, 03:55 PM EDT

The semiconductor giant tells CRN that it is 'winding down' the company's portfolio of high-tech cameras and sensors that were built for computer vision applications like robotics and digital signage to focus on its core businesses. The company will honor current customer commitments, and Intel plans to apply the technical expertise and talent it developed in computer vision to support other functions in the chipmaker's core businesses.

TECH / INTEL

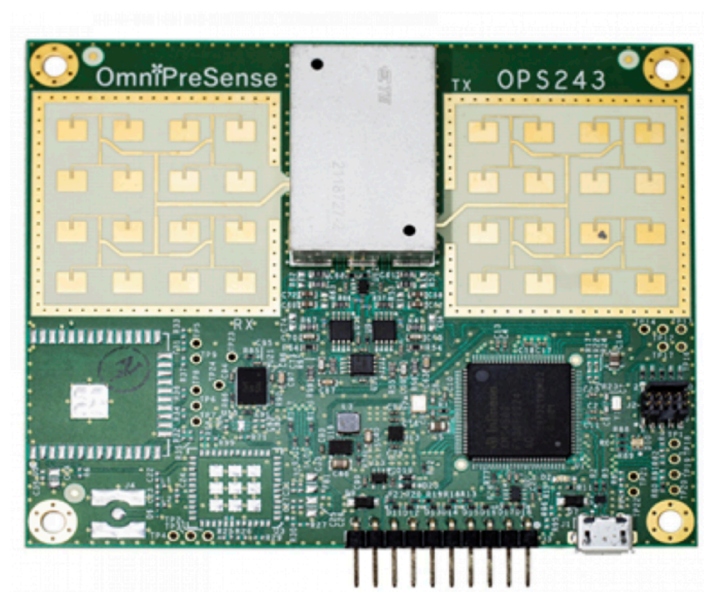
Say goodbye to Intel's RealSense tech by remembering its incredible demos

/ The cameras had some great demos over the years, but Intel is "winding down" the business

By MITCHELL CLARK
Aug 17, 2021 at 5:55 PM EDT | 0 Comments / 0 New

Intel's RealSense computer vision tech will soon be going away, as the company is "winding down" the business, according to *CRN*. If you don't remember the tech from January of this year, where Intel pitched it as a way to create facial recognition systems, you may remember it from some incredible tech demos (or possibly a few devices, if you were really paying attention).

Step 2 has focused on comparing gains from moving processing to the “edge” for primary detection, and seeks to explore correlation algorithms, and sensor fusion techniques. This phase will potentially be using CUDA with the stronger Jetson Xavier,. Our original solutions will be used on the main compute, in tandem with “edge" processing on Luxonis OAK camera platform. This phase will additionally show the team forcing ourselves over to ROS based logic as a huge focus. Sensors from FLIR, OmniPreSense, Luxonis, and Livox are the the base of the current sensor suite.



Luxonis

XAVIER

OmniPreSense

Item	Quantity	Cost	Purpose
Step 2 Prototype phase			**Edge Detection**
Oak-D S2 https://www.amazon.com/dp/B0B5TV1G9R	2	$319.99	Vision System tests
Oak-D Pro https://www.amazon.com/Luxonis-Oak-D-Pro-Fixed-Focus-Robotics-Camera/dp/B0BQ5N681J/	1	$439.99	Vision System tests
Oak-1 Max https://www.amazon.com/Luxonis-Oak-1-MAX-Robotics-Camera/dp/B0BP89H9V7/	1	$249.99	Vision System tests
ChatGPT Plus https://openai.com/blog/chatgpt-plus	12	$20	Tech Support!
PhantomX turret (dynaimixel based) https://www.trossenrobotics.com/p/phantomX-robot-turret.aspx	1	$209	Motion Control tests
Livox Mid-360 https://www.livoxtech.com/mid-360	1	$749	Vision System tests
GetThermal Lepton 3.5 https://store.groupgets.com/products/flir-lepton-3-5	1	$438	Vision System tests
OmniPresence OPS243 https://omnipresense.com/product/ops243-doppler-radar-sensor/	1	$209	Vision System tests
J5 create 360 webcam https://en.j5create.com/products/jvcu360	1	$110	Vision System tests
Logitech C920S webcam https://www.amazon.com/Logitech-C920S-Webcam-Privacy-Shutter/dp/B07K95WFWM	1	$69.99	Vision System tests

STEP 2 LESSONS LEARNED

Edge Processing may be the way to go, but unclear!?

The main thing we learned during Step 2 was that indeed, Intel RealSense most likely won't be a choice for us moving forward. We'll likely keep it as a supported legacy code option for comparisons of our progress. It has however become clear we needed to change camera platforms if anything for availability, price, and how the open source community handles. The neglected feel of Intel RealSense is starting to shine through, and the product line has started to feel long in the tooth.

The winning formula will likely be Edge Processing for basic detections of targets, and correlation data from secondary, and tertiary sensors such as thermal, or Lidar. In the mean time we've explored a rich set of sensor options from multiple vendors for future sensor fusion options.

Even though we are pushing edge based processing we still took a moment to seek beefier main compute units. The Jetson line has served us well in the previous step, so it made sense to move laterally across the Jetson upgrade paths to see what is ultimately available to us GPU wise.

RealSense comparison

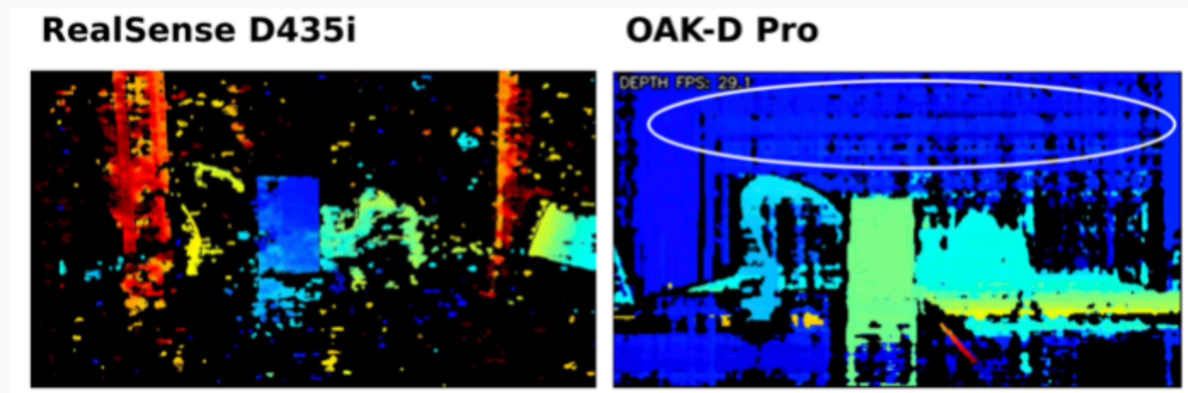
TL;DR: Compared to RealSense stereo cameras, the DepthAI platform adds a **ton of on-device features** (custom AI modes, tracking, scripting, encoding etc.) to OAK cameras and can be used in **embedded applications** (Embedded use-case). **RealSense is also winding down** and cameras are **out of stock**, more information below.

RealSense availability and EOL

In August of 2021, Intel announced it is winding down their RealSense Camera Business (CRN, The Verge). Since then, RealSense cameras are also out of stock almost everywhere. In contrast, all OAK cameras are in stock and we never plan to EOL any of our devices, more info here.

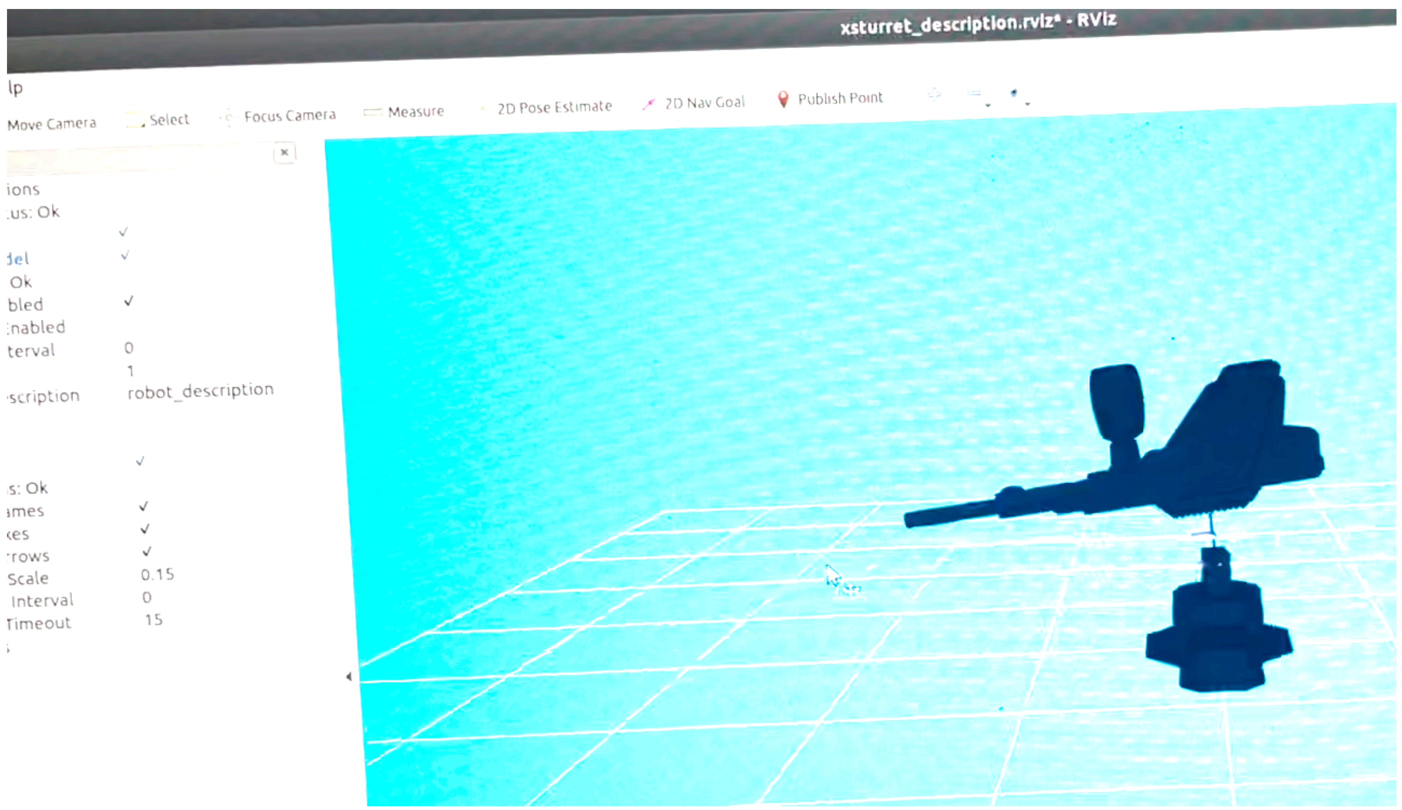
Depth comparison

We haven't done any (quantitative) tests ourselves, but a third party (a customer) sent us their OAK evaluation results, comparing OAK-D Pro with RealSense D435i.



Laser dot projector disabled (passive stereo)

Step 2.1 will be applying all the lessons learned, by further honing and tuning the underlying platform. Both hardware, and software will undergo several more release candidates. The goal will be to move from desk / contrived testbeds to real use *anywhere* the platform is setup. Utilizing ROS based simulation will be key to moving forward at a more rapid pace. Gazebo, and MoveIT will be among the first tools implemented. This is also the point at which we'd like to standardize on a kit we can send potential team members as a hardware SDK / influencer pack.



GAZEBO

MoveIt

ROS 2™

Item	Quantity	Cost	Purpose
Step 2.1 Prototype phase			**Lessons Learned Tune**

This is what our SDK & dev kit looks like!

Although this phase is not yet complete, we are rapidly learning how important it is to have repeatable, and reproducible hardware & software combinations.

The ultimate lesson will hopefully be that our investment in time in the virtual world, and it's supporting infrastructure will bring rapid gains to our ability to prototype better solutions in the physical space that our actual turret occupies.

Having a virtual playground to workout lessons learned from previous steps will be a force multiplier for anyone participating on our team.