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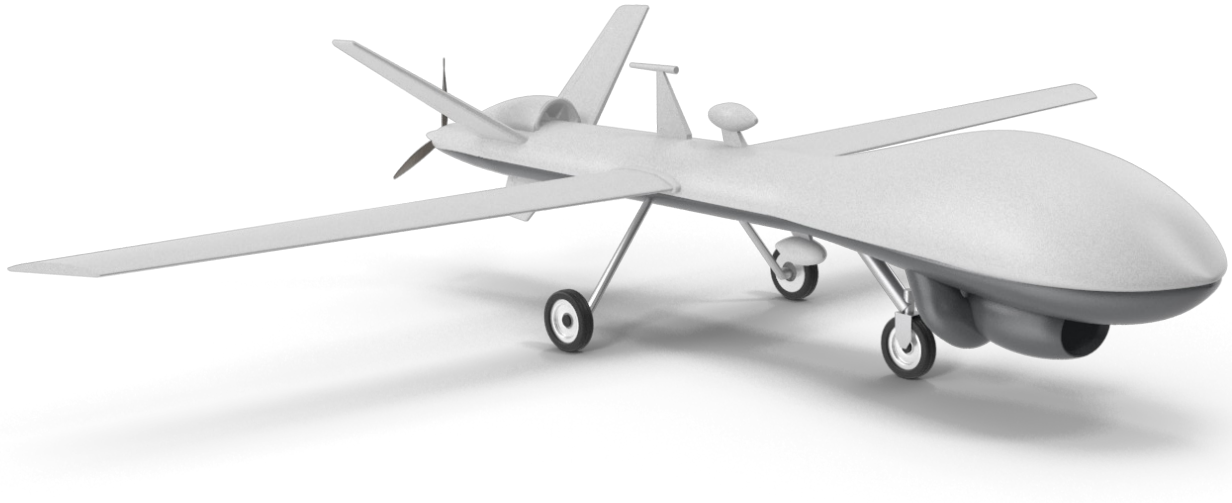
ULTRA FAST OPTICAL TRACKING



DRONE TECHNOLOGY

Offering the low-latency,
no-camera tracking technology
of the future.

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Our Technology

- Reports object or user position/orientation at **blazingly high speed**
- Uses infrared lights as beacons, **does not use cameras**
- Optical **sensors** and **algorithm code integrated** into OEM hardware

This approach offers the unique and sought-after combination of:

HIGH-SPEED PRIVACY ACCURACY

LOW LATENCY LOW POWER LOW BANDWIDTH

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The SIXDOF Advantage

A device using **Sixdof** tracking can transmit lightweight coordinates instead of data-intense photographic imagery. This impacts speed, bandwidth and latency, and is a **performance game-changer.**

Technology works outdoors, indoors, in sunlight and at nighttime.

Drone Target Landings

Guiding that drone down for the last 20-40m is no simple feat, especially in sunlit outdoor environments. The Sixdof technology is the answer for where you need to land a drone — or to hover a drone over — a stationary platform or moving deck.

The Sixdof sensor unit is installed on the drone, aiming down. When the drone locks into the coded beacon that is installed on the landing platform, the drone receives directions from the sensor to guide it into a targeted landing.

In areas with multiple landing options, each beacon flashes a unique code for the sensor to see and to know which to target.

We can provide centimeter level accuracy relative to the target beacon.

Collision Avoidance

Multiple drones flying together in a swarm currently cannot get closer together then what GPS allows. **The Sixdof technology provides centimeter level accuracy when the drones are less than 10 meters apart.**

Drones, enabled with the Sixdof technology, can know when they are getting too close and immediately send a signal to adjust their flight paths.

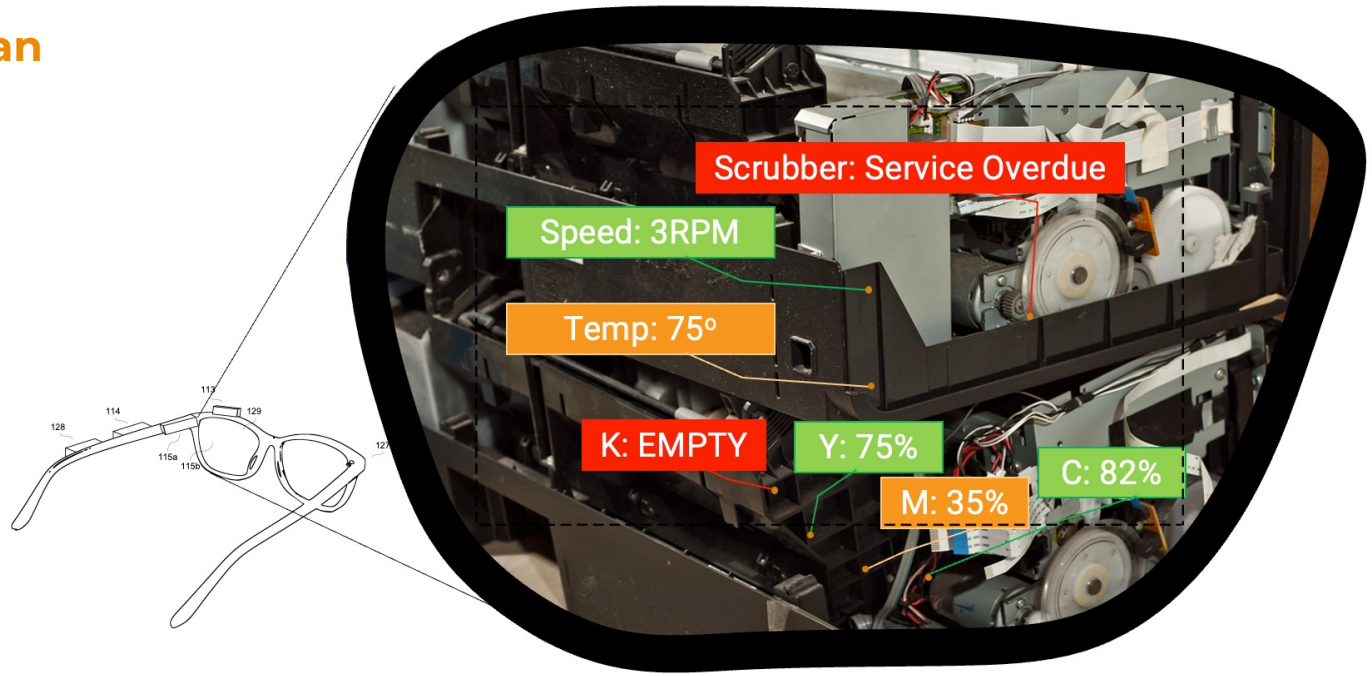
Each drone has Sixdof sensors and beacons installed on both sides of the drone. Tracking both sides simultaneously.

ALL THIS WITHOUT GPS
WE WORK IN GPS DENIED ENVIRONMENTS

Short Message Communications

Using the Sixdof DSAR technology, drones can use the beacons and sensors for communication of short messages.

These messages can enhance both targeted landing and collision avoidance use cases. It works when other radio frequency message options are being jammed or inaccessible.



The Sixdof DSAR technology was developed for our Augmented Reality use case and is an acronym for Dynamic Status Augmented Reality.

COMPETITION ADVANTAGES

Camera Based Tracking Systems

Sixdof Technology is faster, private (as we are not taking a full picture) and works both at nighttime and daytime (sunlight).

IR-Lock

IR tracking technology for guided drone landings.

Customer feedback has told us that system struggles in sunlight

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THE SOLUTION:
How we do it

- Custom **compression optics** and **linear sensor modules**
- Reliably analyzes and tracks the optical signatures of multiple light sources simultaneously
- Minimal computational overhead
- Lightweight Optical Compression visual SLAM capable of mapping and tracking 6DOF position based *solely* on viewing existing lighting fixtures* or coded infra-red LEDs to serve as location beacons.

* Use of existing light fixtures has been technologically proven. A coded beacons approach, however, offers multiple advantages and is currently the design focus.

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TECHNOLOGY
Principles

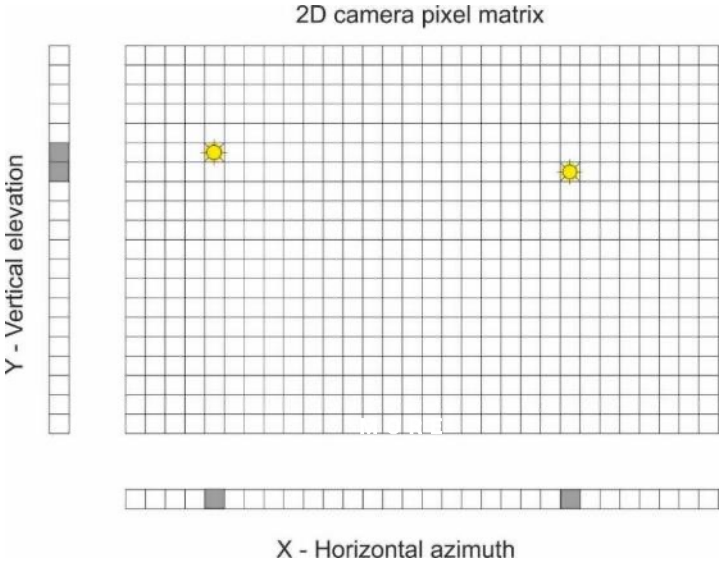
1. Performs **image compression** in the optical domain
2. Maintains **high horizontal visual entropy** during compression
3. Uses specialized optical sensors to **move data** to electrical domain
4. Result is complete tracking along a **single axis**

TECHNOLOGY

Principles

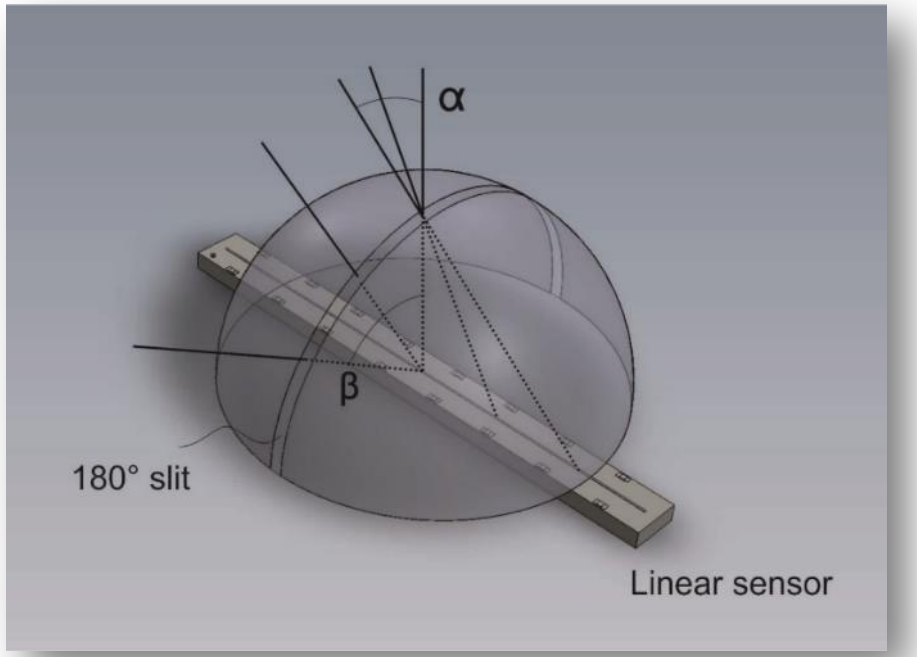
Given a 2D sparse image matrix:

- Sum rows to get a 1D vertical elevation representation
- Sum columns to get a 1D horizontal azimuth representation



Pixel count scales linearly with resolution

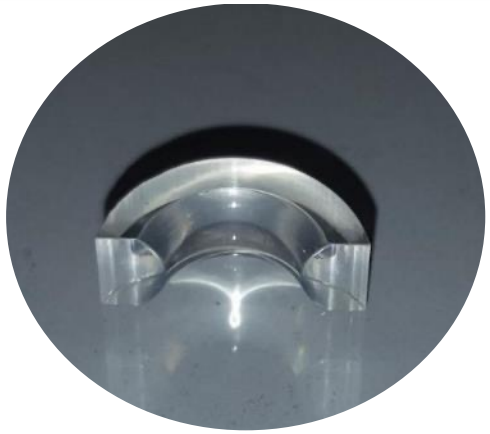
Capture resolution	2D total pixels	2 x 1D total pixels	Data reduction
30 x 15	450	45	**10 x**
640 x 480	307,200	1,120	**274 x**
1024 x 512	524,288	1,536	**341 x**
2048 x 1024	2,097,152	3,072	**682 x**
4096 x 2048	8,388,608	6,144	**1,365 x**



TECHNOLOGY

Optics

- Light from any elevation angle β arriving at a given azimuth angle α will be integrated at the same pixel
- Light from different azimuth angles α will be mapped to a unique pixel on the sensor
- The result is an instantaneous 1-dimensional representation of the 2-dimensional image scene



Aspheric Toroid Compression Lens

- Large field of view (>120 degrees in both axes)
- High optical efficiency – large NA
- Very high image resolution
- Single element optic design

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Positioning, Tracking and Navigation

Absolute Localization with Coded Beacons

- Individually coded infra-red light beacons
- cm-level positional accuracy
- Ability to re-localize if/when tracking is lost due to a momentary obstruction of line-of-sight
- Pre-defined light map
- Support supplemental data transmission over IR channel

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System Architecture

Designed for Low Processing Requirements

- **Front end** - Feature extraction
- **Back end** – Localization and tracking
- Both processes require a **low memory footprint** (<<1MB)
  - No DSP
  - No GPU
  - Can be implemented using fixed-point arithmetic (no FPU)
- Currently running at over **240 frames/second** on a single 32-bit processor core clocked at 1.5GHz

Designed to run on a single core of a low-cost CPU.
Demonstrated on a Raspberry Pi 3B.

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Summary

- Uses existing room lighting as reference beacons
- Low-cost, low-power and installation-free
- Large field of view with very low data bandwidth
- Tracking rates up to 1KHz
- End-to-end latency (motion to absolute pose data) as low as 2ms
- Minimal disruption to work site
- Avoid security and privacy issues of cameras
- Flexible integration

Thank You

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