Henry Morris Memorial Trust Report

I hope you enjoy this report showing what I have been doing for the last 6 months! Without the funding from the Henry Morris Memorial Trust, I would not have been able to undertake this project, during which I have learnt so much, and developed a useful tracking and rendering augmented reality system. So thank you for this great opportunity!

~ Jack Peck

Real-Time Inertial and GPS Assisted Tracking of Objects in 6-Dimensional Space

Jack Peck

Aim

The aim of this project has been to develop a system capable of tracking a small, fast moving racing drone in realtime, and then use this data to render virtual racing tracks and other objects in virtual and augmented reality.

Typical Commercial Drone

~40cm to 1m

Top speed of ~60km/h (40mph)
Max rotational speeds of 200°/s
Max acceleration of ~20m/s^2
after gravity ~10m/s^2

Typical Racing Drone
(This is what I fly)

~20cm

Top speed of up to ~290km/h (180mph)
Max rotational speeds of 3000°/s
Max acceleration of ~150m/s^2
after gravity ~140m/s^2

Example Racing Drone Track

Example line-of-sight (LOS) flying


Example first-person-view (FPV) flying

Viable Tracking Technologies

Global Navigation Satellite Systems (GPS) Tracking

Pros: Highly stable over long periods of time

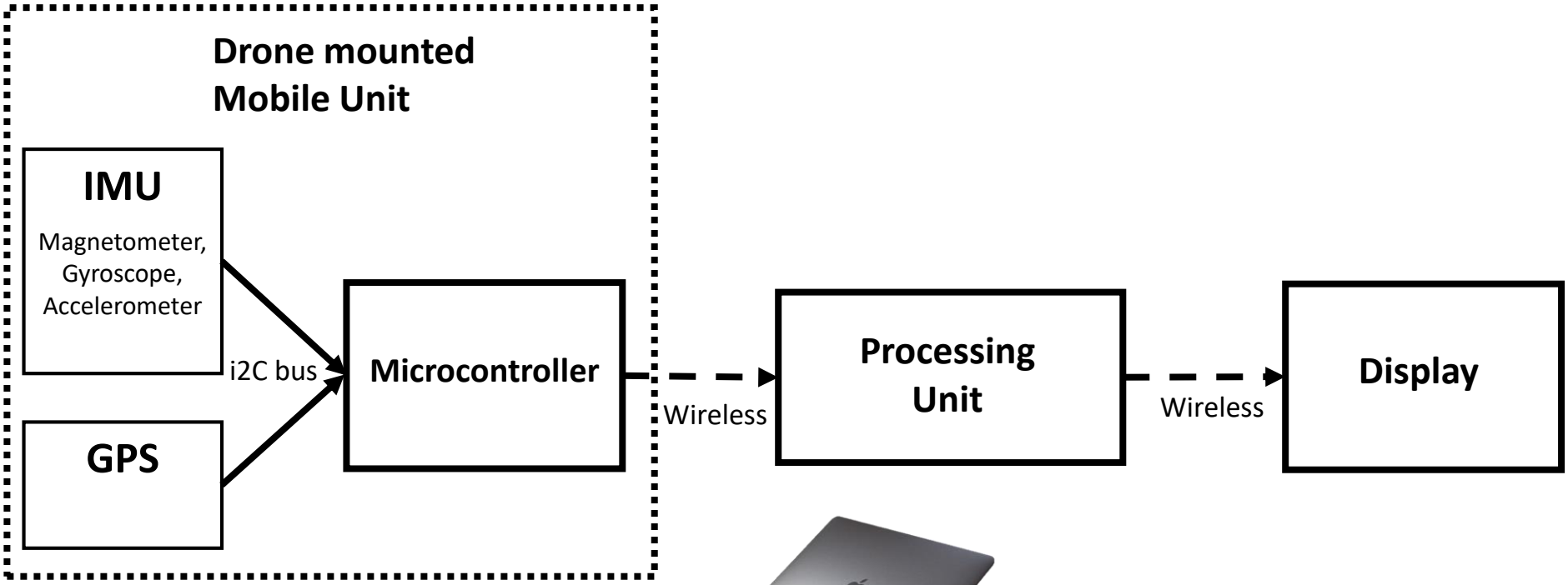
Cons: Low update rate (1-5Hz)
Low precision per data point (±20m)

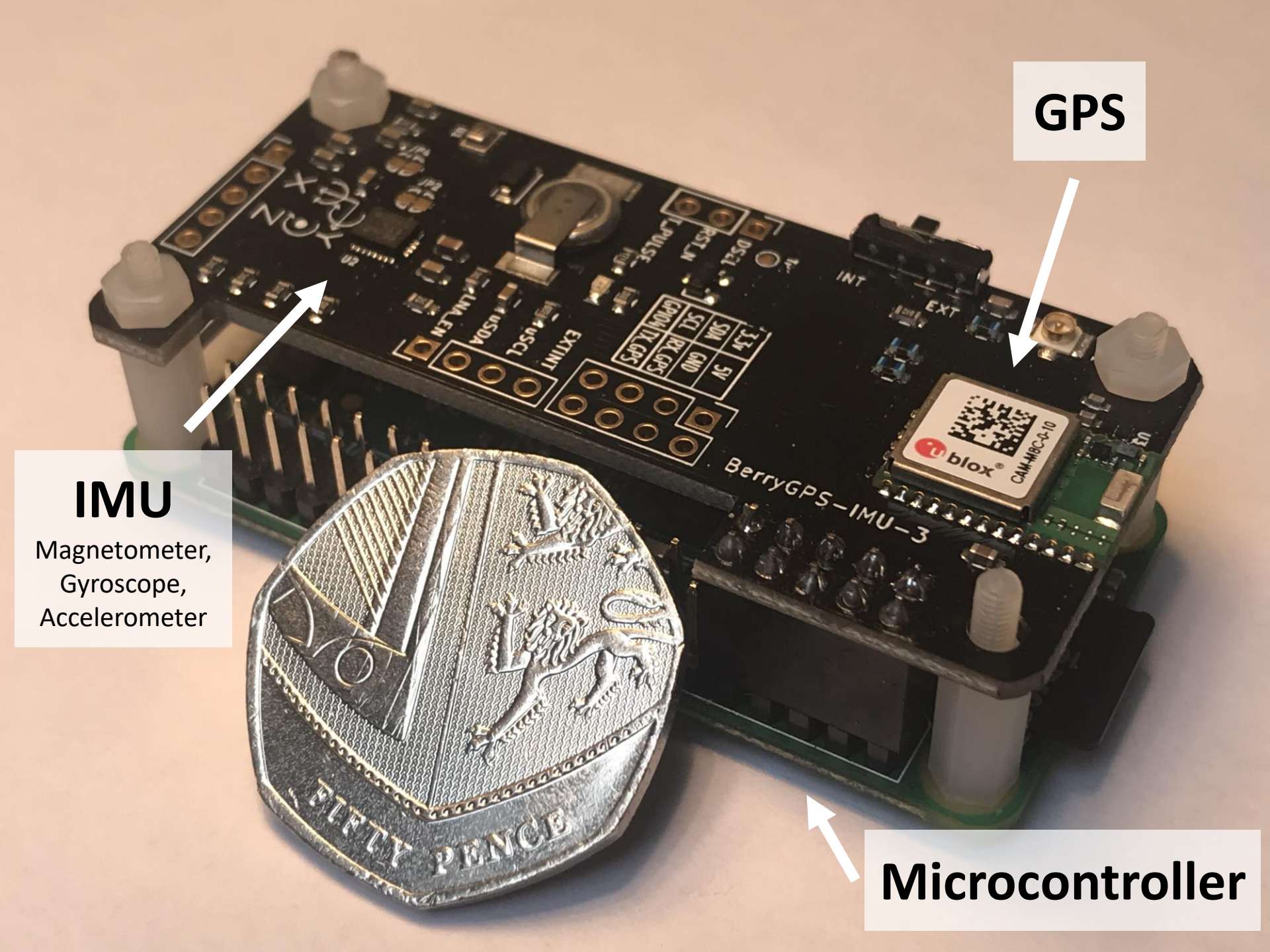
Inertial Tracking

Pros: Highly accurate at determining changes to rotation and velocity over short periods of time.

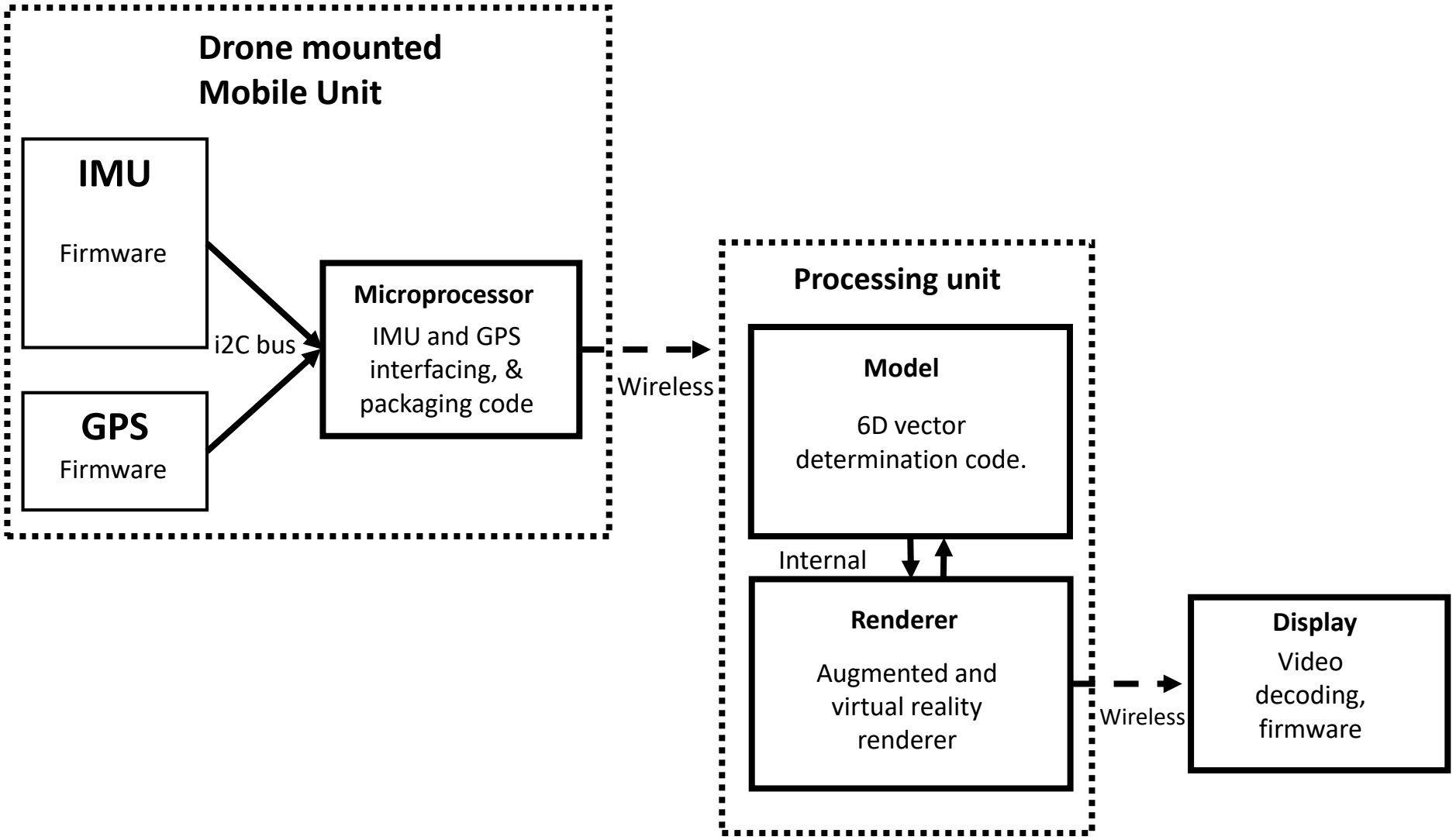
Cons: Highly unstable over medium/long time periods

Hardware Schematic

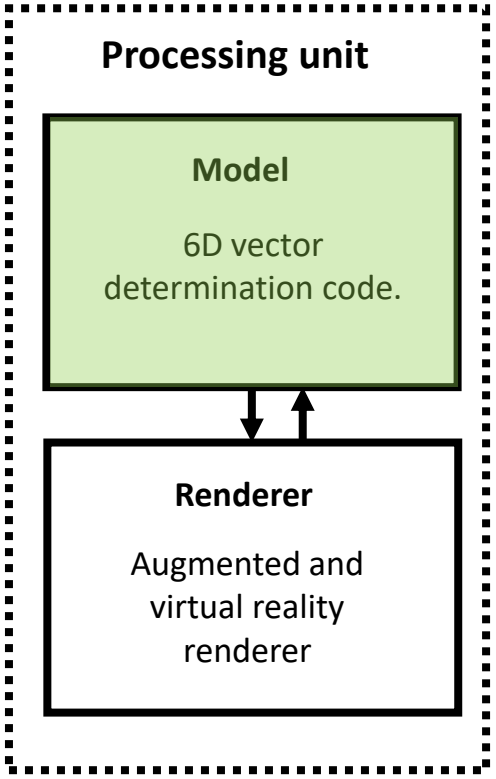



GPS
IMU
Magnetometer,
Gyroscope,
Accelerometer
Microcontroller
BerryGPS-IMU-3
FIFTY PENCE

Software Schematic



Software/Model



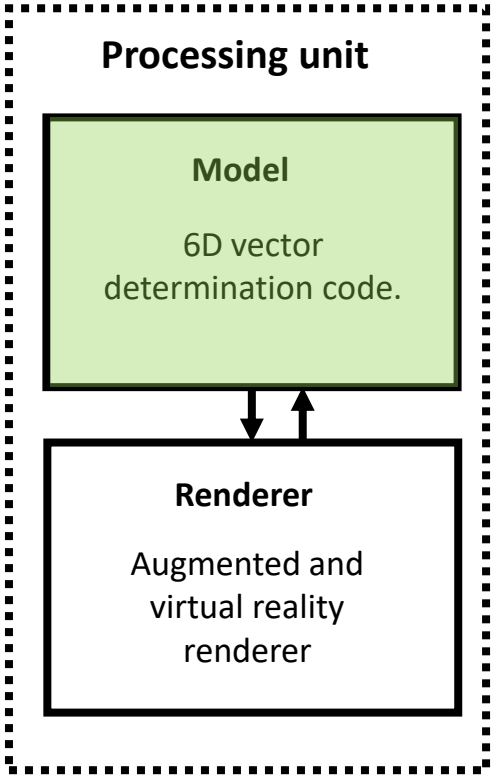
Base Model

A set of functions that process the IMU and GPS data and return a set of 6D vectors containing the position and attitude of the tracked object.

Has many parameters built into it that allow for variance of the effects, significance and speed of parts of the model.

Parameters can be set statically or changed dynamically based on functions of the sensor data streams.

Software/Model

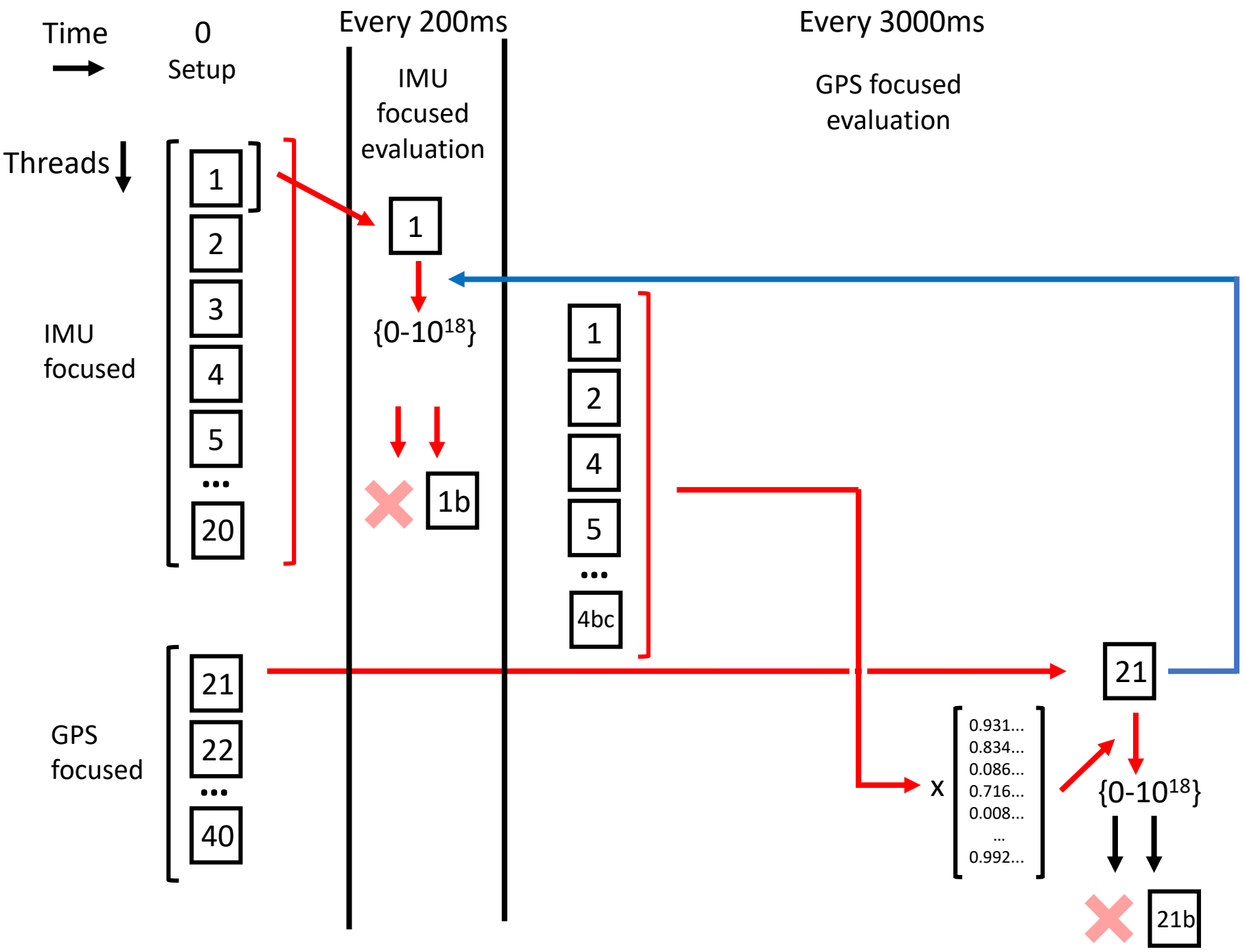


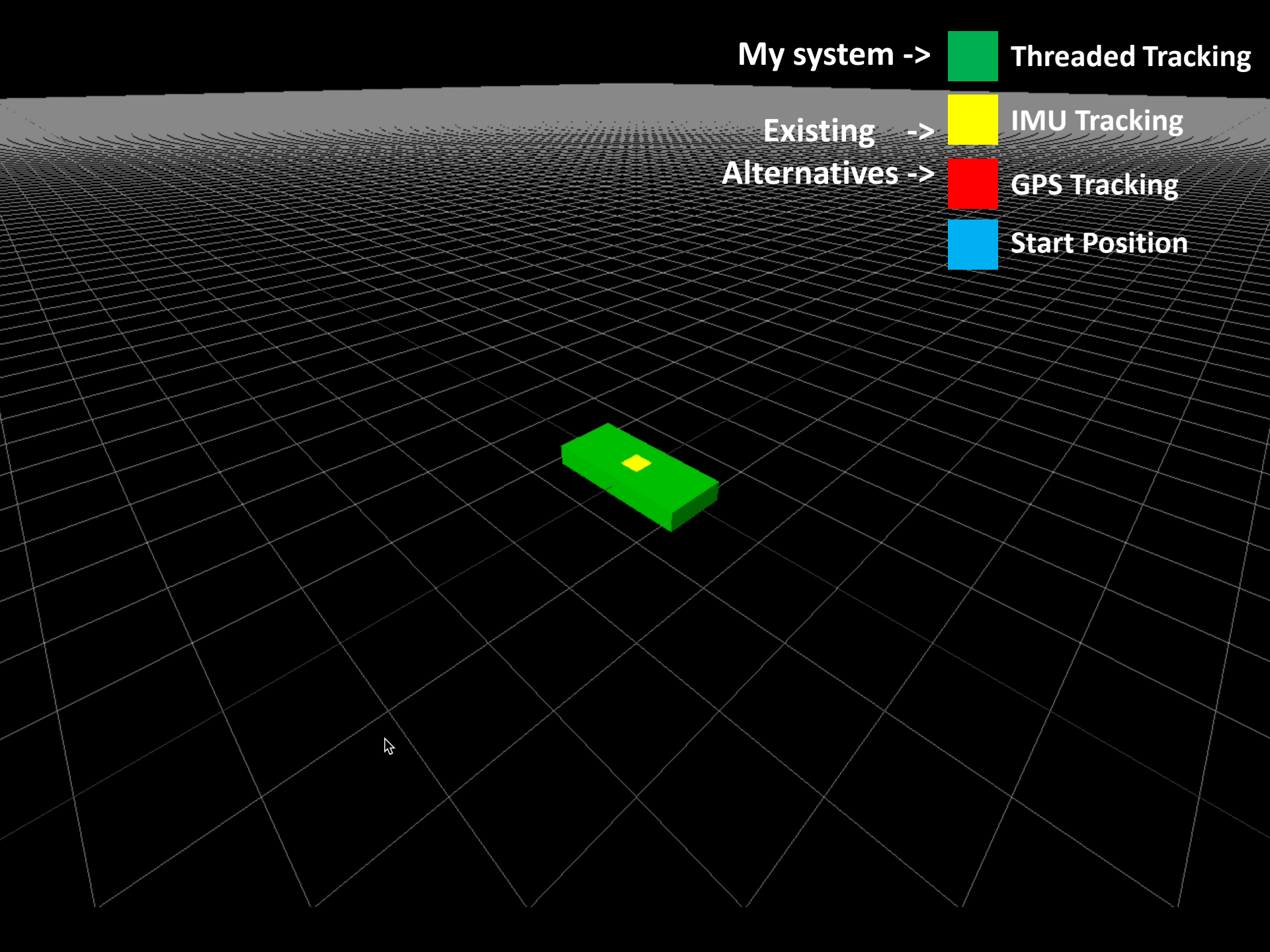
Threads and Thread Evaluation

A thread is a set of parameters that are either used to vary the base processing model version specific to the thread or used internally.

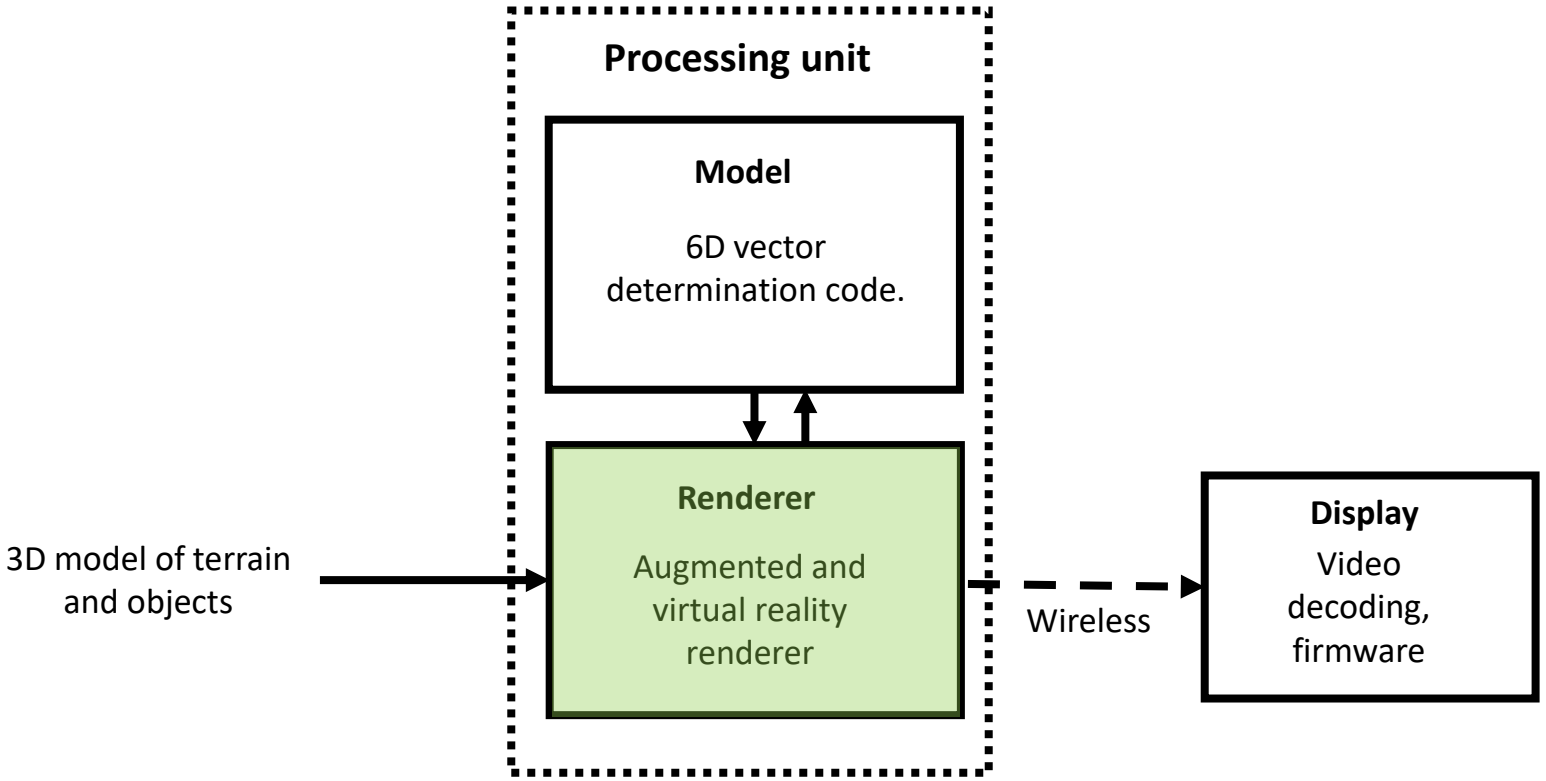
The hardware used can run a maximum of ~500,000 threads iterations per second,
equivalent to running and evaluating several hundred concurrent threads at 100Hz.

Each thread produces a set of 6D vectors.

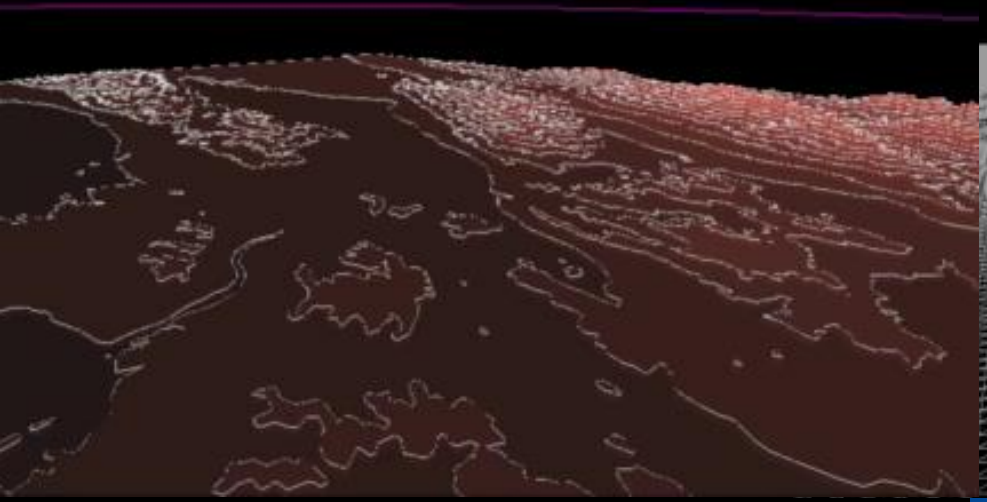

Time
0
Setup
Every 200ms
IMU
focused
evaluation
Every 3000ms
GPS focused
evaluation
Threads
IMU
focused
1
2
3
4
5
...
20
1
{0-10^18}
1b
1
2
4
5
...
4bc
GPS
focused
21
22
...
40
21
x
0.931...
0.834...
0.086...
0.716...
0.008...
...
0.992...
{0-10^18}
21b


My system ->
Threaded Tracking
Existing ->
IMU Tracking
Alternatives ->
GPS Tracking
Start Position

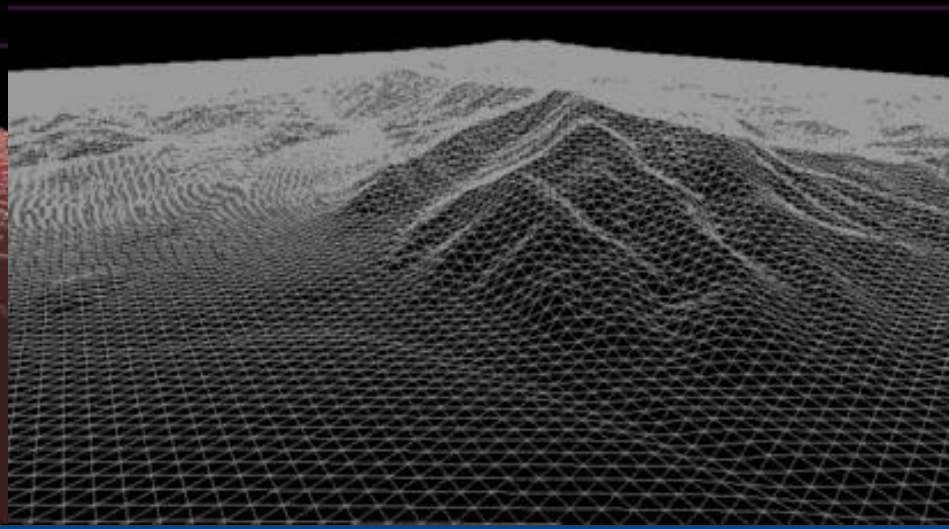
Renderer


Processing unit
Model
6D vector determination code.
Renderer
Augmented and virtual reality renderer
3D model of terrain and objects
Wireless
Display
Video decoding, firmware

Contour map



Wireframe model

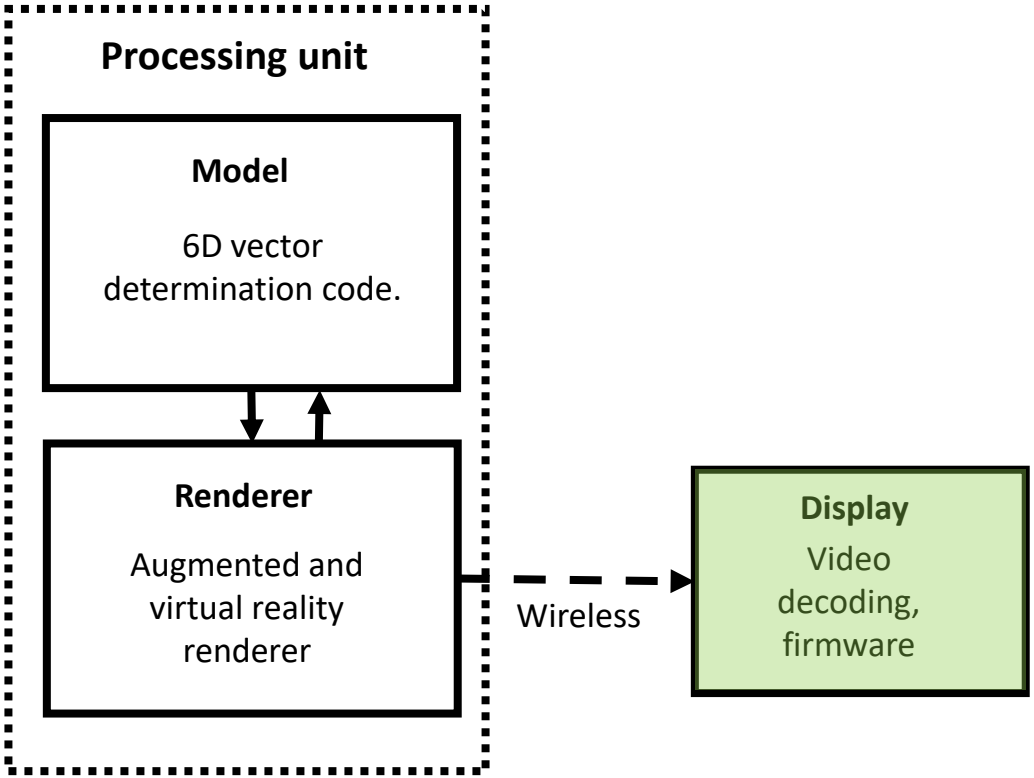


Wireframe + satellite imagery

Models of small objects

Example Single Frame Render

Display


Processing unit
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Example first-person-view (FPV) flying

Final tracking + rendering system - Example AR render

This flight was actually in a field near my house, with the tracking and rendering system used make it appear like a virtual environment based on Hollywood Hills.