INDIVIDUAL PROJECT

LAND MINE DETECTION AND LOCALIZATION USING SWARM LAND ROBOTICS

BY –

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Minotrons

There are estimated 110 million Anti-personal landmines all over the world. The aim of Minotrons is to detect and localize these landmines, without triggering

Design Considerations –

A. Weight less than 6 Kgs (not triggering the pressure plate of land mines.

B. Land may be uneven, with dust/dirt, but should be hard enough.

C. Area without vegetation is preferred.

D. Cost/efficiency should be balanced in case of detonation.

E. Sensor should sense different kinds

Fig. 1

The Idea –

My design consists of swarm robots which will detect and localize land mines.

The design is compact, cost-efficient, and has differential-two wheel drive mechanism which can maneuver non-uniform lands.

Sensor used for detection is ground penetrating radar***(abbreviated as GPR in other slides)** which currently is bulky, but research promises that they can be compact in near future. An ideal size is taken into consideration for preserving compact design.

A central processing computer will generate a heat-map with probability density of land-mines.

Supplementary mobile beacons will be deployed along with detector robots which will serve as a recharging unit as well as communicators with the CPU.

Fig. 2

Fig 1. –
Demonstration of how deployment of swarm land robots in the field would look like. This does not reflect my idea of robots or application. Link.

Fig. 2. –
Size estimate given for GPR by comparing with human. Link.

The Design

Fig. 3 – Deployment of Minotrons in the field

Design is compact, with two wheel differential drive, the body is designed with carbon fiber epoxy resin 3mm thickness, but PLA (other 3D printer materials) can be used for lighter and quick manufacturing.

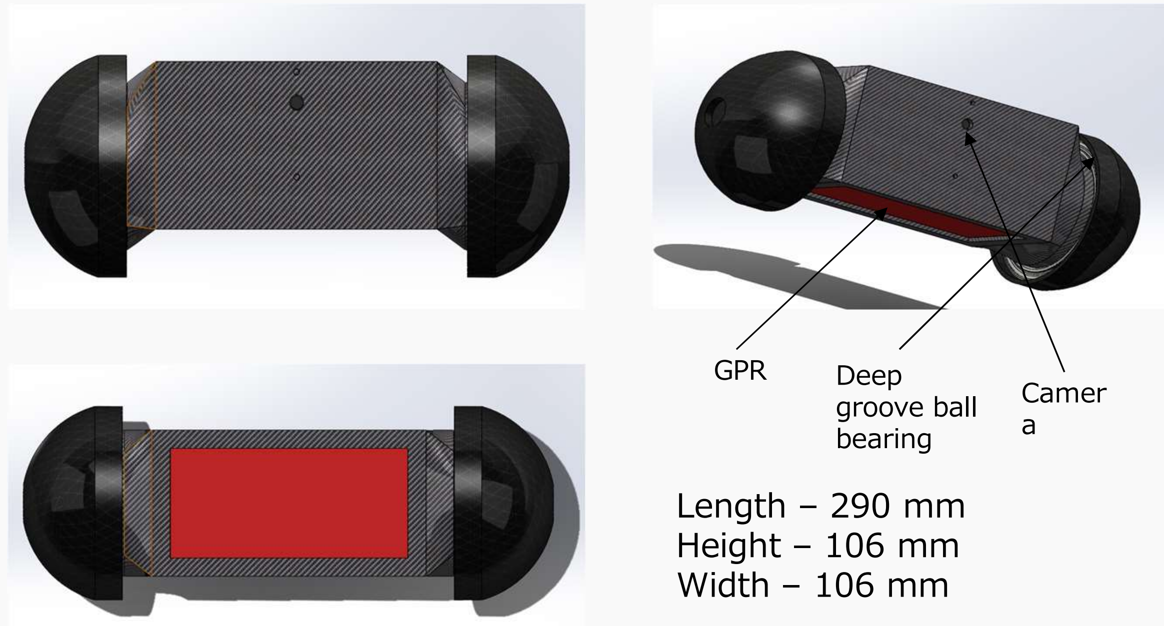


Fig. 4 – Front and bottom view of a Minotron, along with tilted bottom view of Minotron.

From the figure we can see the camera position in the front view and the GPR (ground penetrating radar) positioning in the bottom. Other sensors, which include GPS and IMU along with hardware are positioned inside. Ensuring no interference, GPS can be positioned on top with protective casing. The center of gravity which plays an important role in driving (since Newton's third law will cause our robot to wobble), it is intended to be in the central bottom position.

The Design

Designing Motor and Battery.

- Motor – A geared DC motor is used for differential driving. This motor is designed with parameters – Robot weight, nominal speed, max slope, and traction in different grounds. Then, motor characteristics curves are used to best estimate the required motor.
- Battery – Hotel load (functioning of GPS, GTR, IMU, Camera, Microcontroller) and Power load with factor of safety is calculated. Then working period is assumed as 40 minutes. Power requirements are calculated and then the battery parameters are

Motor Specifications - link

24V DC Gear Motor (10mm)

Voltage	3 - 24V
Load Current	150mA
Rated Speed	17-3917rpm
Rated Torque Max. (gf.cm)	500-1000gf.cm
Rated Torque Max. (mNm)	49.03-980.7mNm
Reduction Ratio	3-809
Overall Length	24.7-34.0mm

Fig. 5 – DC geared motor

Battery Specifications – 2 24V rechargeable Li-Po batteries are used for application - link

Spec.
Minimum Capacity: **2200mAh**
Configuration: **3S1P / 11.1v / 3Cell**
Constant Discharge: **25C**
Peak Discharge (10sec): **35C**
Pack Weight: **188g**
Pack Size: **105 x 33 x 24mm**
Charge Plug: **JST-XH**
Discharge plug: **XT60**

Fig. 6 – Lithium-ion Polymer battery

Algorithm for deployment

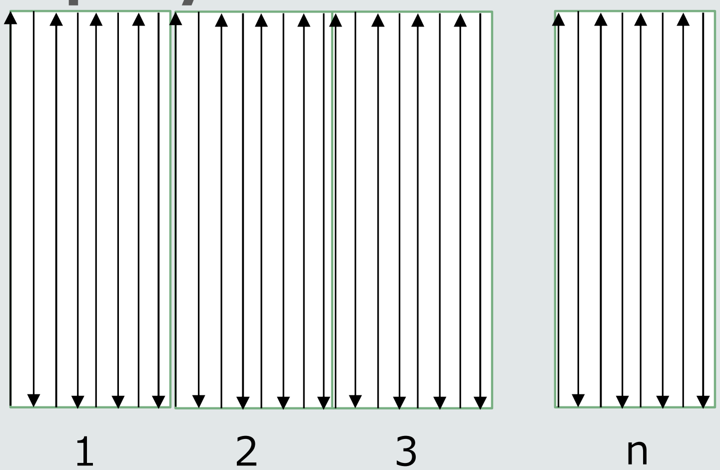


Fig. 7 – Simplified path-planning for Minotrons

If we have to cover area A, then we would first slice the area into n equal sub-areas where n = number of Minotrons. It will be then divided by m forward and backward surveillance as shown in the above figure. These need not be fixed paths, but intelligence will be present for obstacle avoidance using camera feedback.

The intended detection is trained on different kinds of landmines, so that we can perform co-relation analysis with existing GPR signatures.

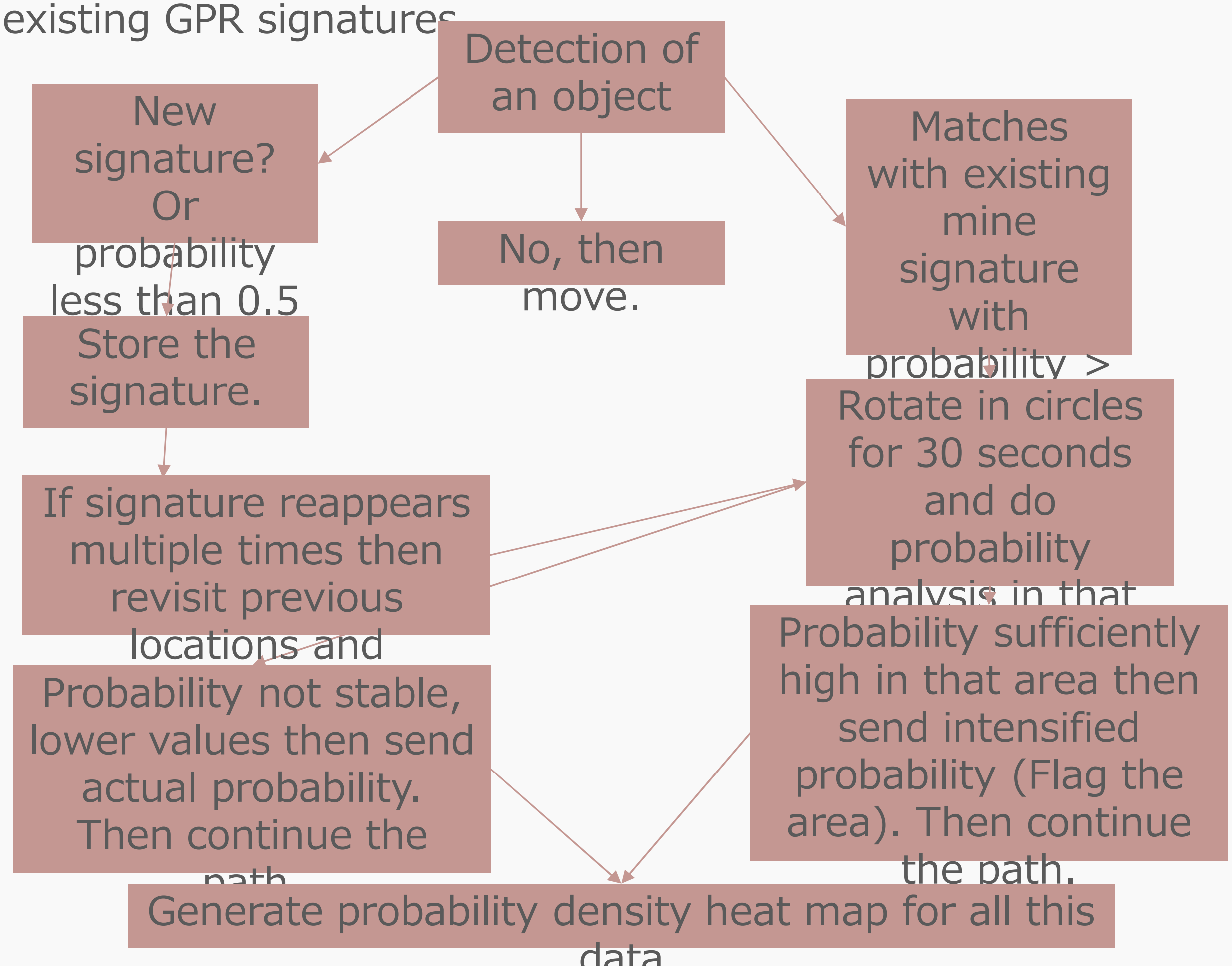


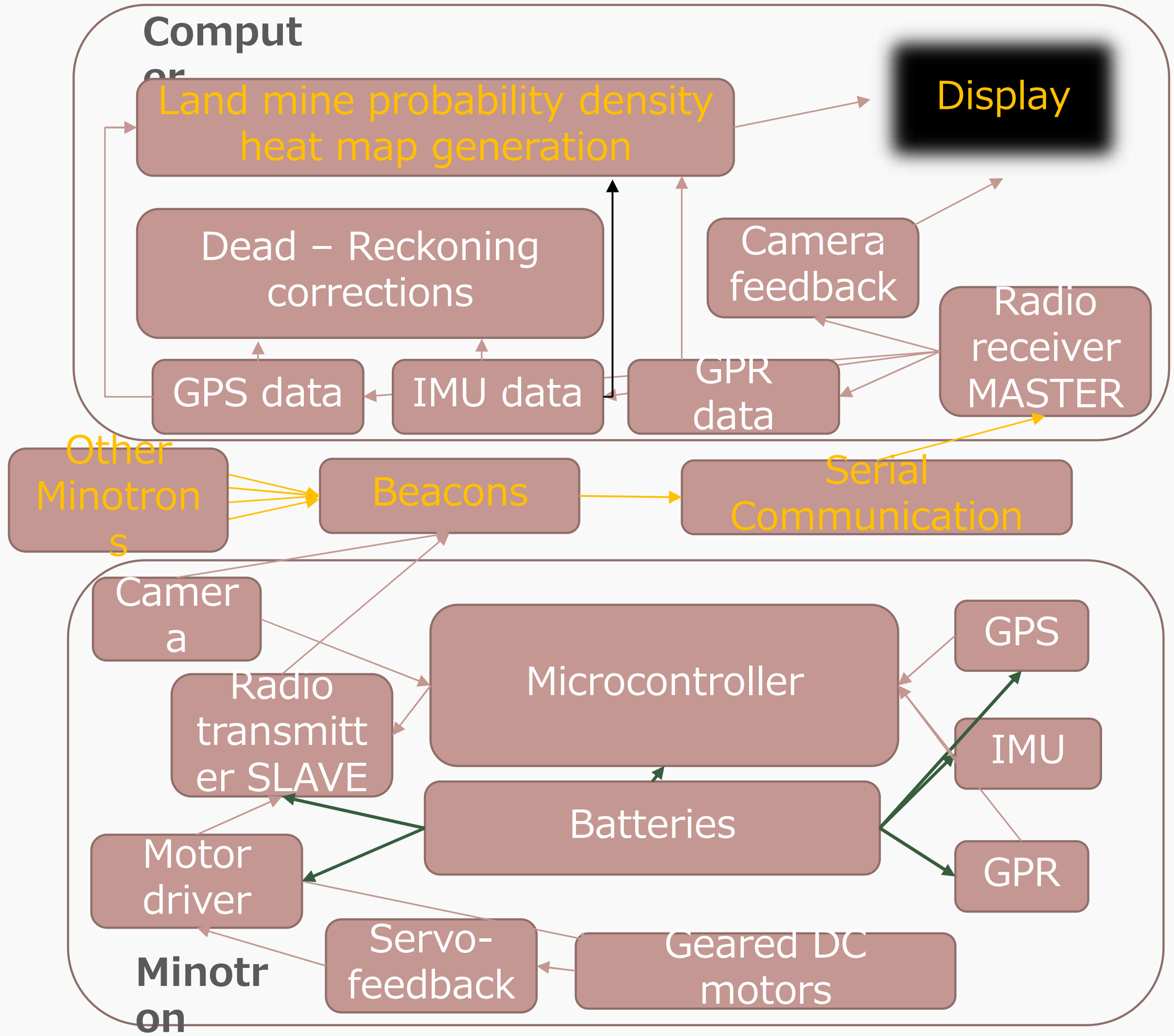
Fig. 8 – Algorithm for intelligent localizing

Architecture

The architecture is divided into two sub-systems- The Minotron which is the deployed drone for detection of land mines –

- The Minotron consists of a microcontroller for driving, detection, and processing of sensor data. The sensors used are real-time kinematics GPS, Inertial measurement unit, and Ground penetrating radar. These are processed according to the algorithm mentioned earlier. The camera feed is used for obstacle avoidance and surveillance. Batteries provide regulated voltage to the devices using voltage regulators. Motor driver is used for differential drive with servo feedback for accurate translation.
- The Central processing unit collects all the data (GPS and GPR) from different Minotrons and this is fused to generate a probability density heat map over the inspection area. The individual camera on each Minotron is used for real-time tracking and visualization via display. We also have a fail-safe if GPS location quality degrades, where we use dead reckoning via IMU until quality is restored. The dead-reckoning position is

*In yellow means cumulative processing for multiple Minotrons
*In green means regulated voltage



Sensors

Ground penetrating radar (GTR)– It consists of transmitter for Ultrawide band radar emission, and a receiver to obtain signature reflected from the object.

GPS – An RTK GPS is used for transmitting relative position with respect to beacon (The communicator with the CPU/ battery rechargeable mobile device)

IMU – In case quality of GPS degrades/or it stops transmitting positions, we'll estimate position with the help of IMU outputs. We'll perform real-time corrections to IMU positions using data-fusion with GPS till we only need to perform dead-reckoning. Once, the GPS is activated we can localize the position of detected mines in non-GPS area with certain accuracy.

Beacons/Radio transmitters – We are using beacon for extension of communication boundary and radio transmitters for communication between them.

***Any information derived from other sources are attached with link to follow.**

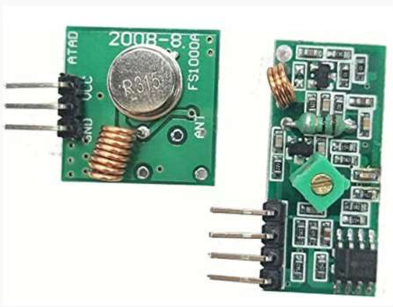
RTK GPS - link

- Receiver: 72 channels u-blox M8P (GPS L2C/A, GLONASS L1OF, BeiDou B1I)
- Processor: STM32F302
- IMU: ICM20948
- Navigation update rate: max 8Hz
- Positionning accuracy: RTK Fix - 0.025m + 1 ppm CEP
- RTC crystal
- Communication: CAN
- Connectors: JST-GH
- Operating temperature: -40°C to 85°C
- Dimension: 76 x 17 mm (ø x h)
- Weight: 50 gr

VN110 – size 56 x 56 x 23 mm - link

< 0.05˚	**< 1˚/hr**	**< 10 µg**
Static Pitch/Roll	Gyroscope In-Run Bias	Accelerometer In-Run Bias
±15 g	**±490˚ or ±2000˚/s**	**800 Hz**
Accelerometer Range	Gyroscope Range	IMU Data

315Mhz RF Transmitter and Receiver Module - link



HiLetgo 315Mhz RF Transmitter and Receiver Module link kit for Arduino/ARM/MCU/Raspberry pi

Receiver module parameters:
1.Product Model: MX-05V
2.Operating voltage: DC5V
3.Quiescent Current: 4MA
4.Receiving frequency: 315Mhz
5.Receiver sensitivity:-105DB
6.Size: 30 * 14 * 7mm
7.External antenna: 32CM single core wire, wound into a spiral

Technical parameters of the transmitter head
1.Product Model: MX-FS-03V
2.Launch distance :20-200 meters (different voltage, different results)
3.Operating voltage :3.5-12V
4.Dimensions: 19 * 19mm
5.Operating mode: AM
6.Transfer rate: 4KB / S
7.Transmitting power: 10mW
8.Transmitting frequency:315Mhz
9.An external antenna: 25cm ordinary multi-core or single-core line
10.Pinout from left → right: (DATA; VCC; GND)