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Gesture based terrain mapping and recognition-overview

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Abstract. Up until a few years ago, the only way to get an aerial overview of a designated area was to fly over it with a manned aircraft and physically inspecting the areas or taking pictures of it. Unmanned Aerial Vehicles, have been a blessing to all the industries which relied on aerial images or drawings for their work. Unmanned aerial vehicles also knows as drones, in more colloquial terms, is a blessing to all industries in the world. The cost of manufacturing and assembling drones have gone down significantly as majority of people adapted to using it. The film industries are using it to get excellent footage with accurate direction and lighting. Civilians can use it as toys. Students can use it to learn avionics and flight mechanisms. Youtubers use it for professional high resolution footage. Rescue teams use it for surveying the area. Armies use it to get a tactical advantage in a firefight and recently, Amazon is using drones for superfast delivery service. The possibilities are endless if properly invested on. Machine Learning and Artificial Intelligence are next best thing in the field of Computer Science and that’s why I plan to merge these two fields and present something which fundamentally adds more features and a hive mind facility to even work without a commanding signal.

1. Introduction
The current real time terrain mapping, usually carried out by Self Drive Cars usually use the overlay of the map to find directions. The on board computer of the car, usually uses a bunch of sensor like: Proximity Sensor, Stereoscopic Cameras to identify objects and cars in its trajectory. This method very viable for cars because it has less to no space constraints to house the compute power. I propose a method to identify terrain defects for tactical combat and rescue operations by dividing the work into terrain recognition and terrain mapping.

The Operator is the person who controls the drones and provides the drones with directional data for it to follow. There is also an autopilot which takes over the controls when no gesture commands are received for a while.

2. Levels of Autonomy according to the United States Department of Defense
Level 1 - Human operated system in which a human operator makes all the decisions regarding drone operation.

Level 2 - This system can perform many functions independent of human control. It can perform tasks when delegated to do so, without further human input. Examples are engine controls, automatic controls, and other automation that must be activated or deactivated but a human.

Level 3 - The third level of autonomy is a human supervised system. This system can perform various tasks when it is given certain permissions and directions by a human. Both the system itself and the supervisor can initiate actions based on sensed data. However, the system can only initiate these actions within the scope of the current task.

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Level 4 - The final level of autonomy is a fully autonomous system. This system receives commands input by a human and translates these commands in specific tasks without further human interaction.

3. Literature Survey

There is a lot of interesting research in the field of Drone technologies, and the major players are including 4k video recording, object tracking, directional sense, and a lot more. They offer a lot of features and have a high price tag associating with it.

The DJI Spark is one of the commercial drones available for the common public and it has gesture based control system. According to Paul Pan, the Senior Product Manager at DJI, "Controlling a camera drone with hand movements alone is a major step towards making aerial technology an intuitive part of everyone's daily life, from work and adventure to moments with friends and family." There are numerous research papers associating with the gesture recognition in a drone system. The majority of them using Motion Controller or sensor like the Leap motion controller or the Kinect controller.

The pitch and yaw(movement) is controlled by the hands and the gaps in communication are filled with the autonomous drive controller. An important distinction within the concept of autonomy is the difference between automatic and autonomous systems. An automatic system is a fully preprogrammed system that can perform a preprogrammed assignment on its own. Automation also includes aspects like automatic flight stabilization. Autonomous systems, on the other hand, can deal with unexpected situations by using a preprogrammed ruleset to help them make choices.

As described by the levels of autonomy according to the United States Department of Defense, it is ideal to have a system which is at level 3 at all times and can initiate level 4 when no human input is received, i.e. the drone system will always be under gesture control and when no gesture input is received, the internal flight controller of the drone can take over its control.

3.1. Current Work on Flight Controllers

1. PX4 – PX4 is part of the Drone code Project, a shared and collaborative open source project to deliver a complete end-to-end platform for unmanned aerial vehicles (UAVs). A complete auto pilot system for large drones [1].

2. Flight Controller – This is a microchip which is programmed to use sensor data from the sensors in the drone and use it to keep the drone stable [2].

3. Autopilot Hangar - a multi headed/ Hybrid- controlled drone management system which has an autopilot system [3].

4. Motion Tracking in drones – Numerous Open Source organizations provide code to implement for motion tracking.

The second important task in this system is the mapping system. Many companies including google are doing this using various algorithms. The algorithms are primarily known as SLAM or simultaneous localization and mapping. These algorithms are not always known for their accuracy and use sensor data to make an approximate map of a local area.

3.2 Current Work on Terrain Mapping

1. Terrain Mapping in Real-Time: Sensors and Algorithms - this paper presents an overview of the work being conducted at the Australian Centre for Field Robotics (ACFR) into sensors and systems used for real-time terrain mapping [4].

2. Vision-based LIDAR (Light Detection and Ranging) Integration: - multiple sensor based mapping algorithms on a land traversing rovers for mapping the terrain in a very accurate manner [5].

3. A Set-Theoretic Algorithm for Real-Time Terrain Mapping of Mobile Robots in Outdoor Environments - rough terrain environments for mobile robots. A few experiments have been carried out in this method [6, 7].

4. Elastic Terrain Mapping – A terrain mapping system used by some projects in NASA, National Aeronautics and Space Administration for terrain mapping using land bots [8, 9].

All the mapping systems implementations, if implemented in real-time cost huge computing resources and cannot map accurately. The most accurate is the LIDAR based Mapping as it is used in self drive cars and other heavy vehicles with ample computing power.

4. Methodology

There are several attempts for real-time mapping using drones but most of the projects are pretty much at its infancy as they all try to map the terrain in real time. They all require huge computing power since terrain mapping requires huge resources.

My plan is to divide the work into 4 parts:

1. Gesture Recognition – handled by an independent flight controller.
2. Drone Pilot – the schedule to be run when no gesture commands are received.
3. Terrain recognition - the schedule to take high resolution images of the area and recognize the pits and outline of the area for tactical use.
4. Terrain Mapping - the Schedule which runs on the a separate high – end computer which uses its compute power and the high resolution images from the previous schedule and maps the area with accuracy.

For the actual system, there should be 2 working computer units.

1. Drone Controller System – a computer specifically to pilot the drone. This computer also listens to the gestures control commands given by the operator and decides on the which schedule to follow, Autopilot or Gesture.
2. Mapping System – the Computer which takes in all the sensor data and segregates the data into the what's required immediately and what will be sent to the EC service for further processing. This unit also communicates to the operator and will relay the terrain recognition data to consumption device.

5. Results

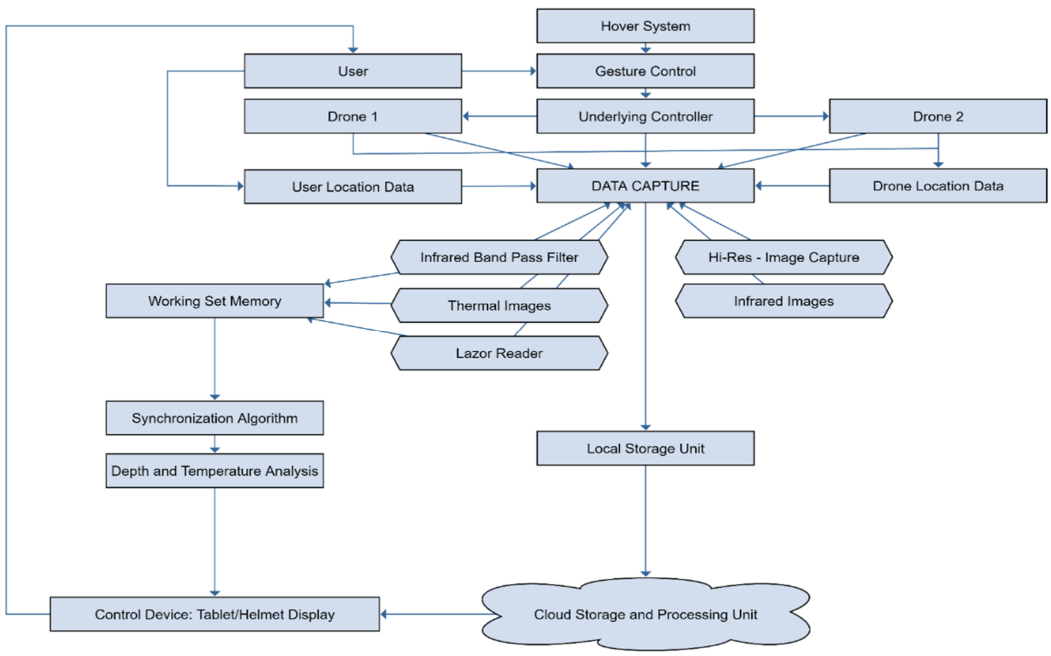

Figure 1. Structure Diagram.

As we see here (Figure 1), there are 2 major zones of work.

1. Which goes to the working set memory (after storing the data to the non-volatile memory) which is required for Real-time data processing to assist the operator of the system navigate through the terrain.

2. The second zone revolves around the data capture and processing the captured data using an elastic cloud service (Scalable Computing). The Scalable Compute Service will process all the data and produce a 3d map of the area which can be used for future endeavors.

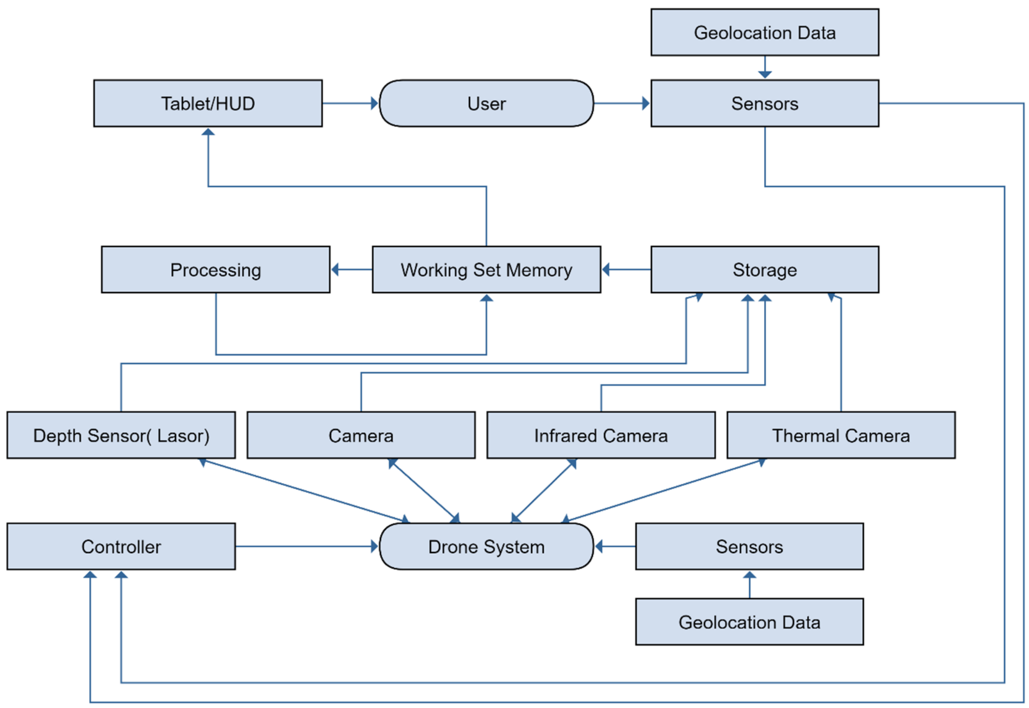

Figure 2. Data Flow Diagram.

The distinguishing part of this system that can be seen here (Figure 2). It will be the fact that this device does not have to process high resolution images in real-time. The computer handling the terrain detection will only produce a depth map using numeric values after calculating the depth and a thermal imaging data can be used for overlay. This data can be sent over to the human operator for physically exploring the terrain. An object detection algorithm like tensor flow maybe implemented in the middle which takes in camera images and recognizes objects and overlays it in the map.

The high resolution images captured can be uploaded to a cloud server for processing. The cloud server can use a commercial or an open source mapping software which used geolocation data and combines it with all the sensor data received and spits out an accurate map of the given area.

Categorization of data in the given concept:

1. Thermal Images.
2. Stereoscopic camera images (high-resolution image capture).
3. Depth sensor data.
4. Infrared Camera Data (for night vision).
5. Generic Camera footage (for relay to the user and use for object detection by Tensor flow).
6. Geolocation data of the Drone as well as the operator.

With 6 the types of data taken into account and then being divided into terrain recognition as well as terrain mapping handled by two different controllers, we can recognize terrain in real time as well as produce a map of that area if needed.

6. Summary

The sole idea of this project was to differentiate between mapping an area and terrain detection to utilize computing resources in an efficient way. The research currently being done in this sphere is phenomenal and when we combine all the research we get different views on how to aliment an idea and the sphere of Unmanned Ariel Vehicle is just at its infancy. We have many different challenges ahead like increasing flight time, increasing signal range and many other things but with the insight I provided, it is certain that all the problems can be solved given time. This article shows the current work being done in the sphere of terrain mapping and drone automation, and combines the two for the inception of a new concept. Further, these tasks can be sub-divided into more tasks for a simpler and faster approach to tackle the problem of terrain mapping and recognition.

Acknowledgments

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