OREOLUWA SEWEJE | SLAM ANSWERS

Question 1 | How would you go about fusing the data from different sensors with different frequencies?

The main solutions are to either synchronize the frequencies, use a fusion algorithm to estimate the time difference between sensors or preprocess data. For the project, I chose to synchronize the frequency between the Lidar and the Imu during the initialization stage and [in theory] estimate the lag during the fusion stage. Linearly interpolating between timestamps that were closest to the Lidar timestamps.

Kalman filters, particle filters etc., can help fuse the sensors. More recently, neural networks can be introduced to fuse sensors.

Question 2 | What role do the covariances play when fusing the data?

Covariance is important for modelling sensor measurement uncertainty used to measure the overall uncertainty of the updated state. In the fusion stage, it is used to weigh each sensor's contribution to the final state. The sensor with lower covariance [higher accuracy] will have a bigger effect on the updated state.

The updated covariance matrix is a combination of all sensor matrices representing the uncertainty of the fused state.

Question 3 | What issues have you faced with the RTK-GPS system? How did you handle them?

I haven't personally worked with RTK-GPS systems. However, common issues that occur from the system:

- Signal loss or obstructions in areas obstructed by tall buildings, trees, going through an underground pass/tunnels or other obstacles, e.g., downtown areas.
- Path errors when the signal reflects off surfaces before reaching the antenna affect measurement accuracy.
- Also, there are regions in which the satellite coverage is poor or not enough coverage or in a new area with a map that's not been updated, so there is no data.

The solution generally is to combine it with sensors that can be relied on when there's no GPS data. Using all possible sensors would be ideal but with storage and limit to processing power [lidar, camera, imu, etc.]. The sensor to use depends on the region and how long it's estimated that the signal will be interrupted. GPS-Visual-Inertial sensor fusion will be ideal.

Question 4 | If one of the sensors has gone faulty during the run-time, how will you handle it?

- The system should have some monitoring system to identify the faulty sensor, and ideally, it'll have details on the issues and steps that can be taken to fix the issue.
- If the sensor is not a primary sensor, backup sensors can be used to maintain minimal accuracy loss. Otherwise, the system may need to be shut down so it can be fixed.
- Lastly, there should be redundant sensors that can be switched to when situations like these happen.

Question 5 | How will you check if the re-localization in a pre-built map was successful or not? Please answer this question for two systems: one with GPS and one without

- For GPS: After re-localization, obtain the ground truth data from GPS and compare it with the estimated GPS position from the SLAM system. It can be considered successful if the error is within a defined threshold.

For systems without GPS, use the sensor with the lowest sensor measurement error, obtain a ground truth value and perform error analysis against a metric. Also, the covariance matrix could indicate the current pose uncertainty as the body begins to move. Lastly, in a slam system, a visual check of the map for accuracy inconsistencies [when compared to the pre-build map].

Question 6 | Why are IMUs used with Lidars and Cameras? What are the common issues?

They are used with lidars and cameras in SLAM systems in areas where Lidars and Cameras are ineffective or not available. For example, in regions with many reflective surfaces, lidar systems may only be effective or cameras in areas with texture/low visibility. In those situations, the IMU will be a complimentary sensor.

Some issues that can arise:

- Calibration issues between sensors as the sensors don't all run at the same frequency. Also, each sensor has its bias which affects the reading. A Kalman filter can help reduce the bias/noise effect
- The sensors are also sensitive to environmental factors, temperature, humidity, visibility, and vibrations.
- Drift occurs in the sensor over time. Things like gravity alignment can help reduce drift.

Question 7 | How will you choose a perception sensor for SLAM? (Kindly mention the common criteria)?

The important factors are:

- Capabilities: This is more environment-dependent; lidars, imu, and cameras all have environments in which they can be maximized. Selecting the right sensor for the right environment is key.
- Cost: Always a trade of when building real-world systems.
- Accuracy: A little hindered by cost, but the data-gathering process is really important for successful SLAM systems and can reduce the amount of preprocessing required, leading to a faster system.
- Robustness and Integration with other systems.