────────────────────────────── Viva Focus Areas

**Objectives and Scope- be clear about project aims**

* Navigation for visually impaired people by developing a wearable system that combines obstacle detection and navigation
* It uses an RGB-D camera, IMU and Visual Simultaneous Localisation and Mapping algorithms to understand its surroundings
* It evaluates two methods of haptic feedback, the knowledge to be used in the future iterations

**How the device addresses current gaps**:

* Shifting from GPS-based systems (unsuitable indoors) to a sensor-fusion-based solution.

**Demonstrate that evaluation metrics are solid, measurable outcomes that map directly back to your stated objectives**.

* Prepare explanations and use video evidence

**Know sensor integration and data processing modules**:

* Understand the role of each hardware component and software nodes:
  + LattePanda for SLAM and point cloud processing
  + Raspberry Pi 4 for navigation and data logging
  + Arduino nanos for IMU and motor drivers
  + obstacle\_detection\_pub.py:
    1. RTAB-map extracts non horizontal points and publishes to “/cloud\_obstacles”
    2. Voxel grid down sampling reduces horizontal and vertical granularity, respectively.
    3. Statistical outlier removal improves the accuracy of obstacles (based on point cloud standard deviation and mean)
    4. RANSAC wall extraction distinguishes planes based on vertical component of plane equation ax + by + cz +d = 0
    5. Obstacles are clustered using the python Point Cloud Library’s Euclidian Cluster Extraction.
    6. Sizes and orientations are estimated using Principal Component Analysis, to identify bounding boxes and hence closest points on obstacles.
    7. Serialised into JSON for compact publishing
  + navigation.py
    1. Converts obstacle locations (closest point on bounding box) into APF forces, and publishes these to the nanos acting as motor drivers.
* Calibration:
  + IMU required manual calibration and a custom package to output IMU data faster than 20Hz
  + 3D reconstructions used to tune obstacle filtering + detection
  + APF calculated using simple vectors to not go within 0.5m of an obstacle

**Why we included both?**

The report says we analysed devices in literature:

Compass:

* The compass system was inspired by the tactile compass (Pielot et al. 2011)
* Uses force feedback instead of vibrations, that were found to cause annoyance to the user (Zheng and Morrell 2012).
* It was seen in (Jones et al. 2006) that haptic feedback on the lower back was easier to interpret therefore this location was chosen for the compass.
* The resolution equivalent to an 8-point compass was adopted due to good directional clarity, which was observed in (Amemiya 2009).

Pulling:

* A shoulder-tapping method was seen to reduce navigation errors and a study found preference over audio feedback (Ross and Blasch 2000)
* This was reinforced by (Prasad et al. 2014) where shoulder based vibrations were successfully implemented demonstrating this methods feasibility.

But behind the scenes, Shou-han provided neuroscience input:

* Compass justification: Having one fixed reference reduces cognitive load and improves haptic interpretations
* Pulling justification: The brain works better for navigational tasks when segmented into left and right
* State that we don’t fully understand the neuroscience behind this.

**Prepare to address the feedback regarding discreet:**

* Emphasise that as a prototype, trade-offs were made
* Clear feedback and utilisation of sensor data were prioritised
* Future iterations will focus on aesthetics and integration into a less obtrusive wearable.

**Be clear about experimental design:**

* Room A vs. Room B- one with one laminate wall and the other with postmodern wallpaper. These were all that were available, so we utilised their features in the environmental discussion.
* Quantitative and qualitative data: questionnaires and performance metrics.
* How is Repeated Measures ANOVA used to compare metrics across conditions?
* Trends:
  + Compass vs Pulling: Some differences between the two systems. The compass system trending toward better performance

**Autonomous Lidarbot:**

* Uses exactly the same Ubuntu and ROS environment as the wearable device
* This enabled learning some project features in a safe environment, with all learnings directly relevant to the future stages

────────────────────────────── Potential Viva Questions and Answers

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| Lecturer focused technical questions | |
| What were the main objectives of your project, and how do your experiments verify that these objectives have been met? | Objectives   * Our primary objectives were to create an indoor navigation aid that integrates robust obstacle detection and intuitive haptic feedback * Evaluating two distinct feedback mechanisms – a compass system and a pulling system.   How we met them   * We designed experiments in two controlled environments (Rooms A and B) using defined metrics such as success rate, collisions, lost odometry, and reaction time. * The overall data confirmed that our approach to sensor fusion, SLAM-based localisation, and haptic feedback integration is viable. * Consistent obstacle identification and directional commands generated are evidence that our design meets its objectives. |
| Can you explain how your Artificial Potential Field (APF) navigation algorithm works? | * The algorithm computes two forces: an attractive force that pulls the system toward a predefined goal, and a repulsive force that pushes the wearer away from detected obstacles. * The attractive force is computed based on the vector from the current position to the goal * The repulsive force is generated by locating the closest x and y coordinate per obstacle, and deriving a net force that translates into discrete navigation commands (such as ‘forward,’ ‘half-left,’ or ‘recovery’ if obstacles are too close). * This method was tested extensively, first through the lidarbot. The performance metrics from our trials confirmed that the approach provides effective guidance. |
| Why APF and not pathfinding? | * We attempted pathfinding on the lidarbot, but the computational load was too intense with the SLAM algorithm * Hence APF was introduced and offloaded onto an arduino MEGA. * We stuck with this structure to retain the link between the two sub-projects. * Pathfinding may still be integrated in future iterations, since the navigation is offloaded onto a separate microcomputer. |
| The current prototype is somewhat bulky and makes the user stand out. How do you plan to address these concerns in future iterations? | * We are aware that a discrete device is needed for blind user acceptance. * In our current prototype, our focus was on achieving functionality, reliable obstacle detection and clear haptic feedback. * However, we used very lightweight components, and future iterations can use any of these components * We opened the path for future years to improve and consolidate the haptic feedback method, for an eventual slim and discrete wearable. |
| What were the main challenges during the integration of the different hardware and software components? | * Original setup and integration, adapting to the linux and ROS environments. * Integrating multiple hardware platforms had difficulties in power and data handling * Too many codependent tuning parameters. The obstacle detection algorithm proved inconsistent across varying environments, materials, colours, lighting and hence each stage of filtering was introduced as these difficulties were discovered. * It is hard to find an optimal balance considering the many different combinations that all impact the system performance and varying computational loads. |
| How does your design compare with existing solutions on the market, and what gaps does it address? | * Existing solutions such as smart canes and walkers or GPS-based navigation aids often fail to provide adequate indoor support * Many require the user to hold the device—hindering natural movement. * Our design combines indoor VSLAM with haptic feedback in a wearable format, providing hands-free operation and reliable indoor navigation. * While current devices might be aesthetically discreet, they often compromise on advanced functionalities that our system offers, such as 3D obstacle mapping and adaptive navigation commands based on the user’s immediate environment |
| Why did you choose these methods of feedback to relay navigation instructions to the user? | * Existing solutions utilised methods such as audio and vibrational feedback * However through literature review issues with both of these methods were identified * Audio feedback performed poorly when the user was in a busy and loud environment as it was difficult for the user to hear the navigation instructions * Vibrational feedback was seen as difficult to interpret and some devices that used this feedback were seen as a source of annoyance for the user * Research showed that shoulder based pulling feedback performed well and was effective * This was also the case with the force feedback based compass system and positioning on the lower back also showed to be the most effective in relaying navigation instructions |
| Passerby Questions | |
| What does your device do? | * The device is a wearable navigation aid designed to help visually impaired people move safely indoors. * It uses a RGBD camera and IMU to map out the surrounding area, identifies obstacles * Gives haptic cues on the back or shoulders to guide the user along a safe path. |
| How safe is the device for everyday use? | * Safety is our top priority. * Our system continuously monitors its performance using dedicated diagnostics that check CPU load, sensor accuracy, and obstacle detection. * The navigation commands are generated based on algorithms that have been tested extensively in controlled environments. * While it is in the prototype phase, all preliminary tests indicate the future potential to effectively prevent collisions and maintain orientation. * Can’t do stairs, uneven floors or weird rooms. |

────────────────────────────── Areas Needing Concreteness

* Discrete
* Issues with lost odometry
* Haptic motor torque
* Design bulkiness
* How the current results inform future design decisions
* Plans for improved sensor integration, and user feedback mechanisms.
* Long-term usability/battery life

────────────────────────────── Final Examination Strategies

* Be honest about limitations and focus on how iterative design and further testing will improve the system.
* Engage both technical and non-technical examiners by preparing simplified, everyday language explanations alongside detailed technical responses.
* Show enthusiasm for the interdisciplinary nature of the project, highlighting collaboration between software, hardware, and user design aspects.