The home-improvement market today lacks a device that allows for a complete depiction of the materials behind walls. While there exist devices that can detect various infrastructure materials, an inexpensive all-in-one device that can detect infrastructure as well as create a sharable visual representation is not available. Such a device would be useful to professionals and do-it-yourselfers alike – where users can scan the wall, save a mapping to their smartphone, and use the information for planning and execution of both large and small scale projects. Our project, WallHack, sets out to build an in-wall infrastructure mapping system using readily-available technology including smartphones, sensors, and microprocessors.

### Hardware Design
- **Data acquisition** is achieved by Walabot’s 3D RF-based sensor. This board includes 18 linearly polarized broadband antennas operating at 3.3-10 GHz.
- **Position feedback** is being implemented by a combination of optical sensor (ADNS 9800) and IMU (LIMR051). Similar to an optical mouse, a signal processor analyzes the change in position by comparing images of the surface as the device moves across the wall.
- **IMU (LIMR051)** consists of a three-axis gyroscope and accelerometer pair that allows for orientation awareness, thereby improving the accuracy of location tracking and eliminating the constraint of perpendicularity with the floor.

### AC Voltage Detector
- **AC voltage detector** is designed using an operational amplifier to bump-up the voltage off an antenna (16 gauge wire). The signal is then passed through a full-wave rectifier and capacitive circuit to convert the 60Hz AC signal to a DC signal.

### CAD Model
- **Data acquisition** is through the Walabot sensor. The board includes 18 linearly polarized broadband antennas operating at 3.3-10 GHz.
- **Position feedback** is implemented using a combination of an optical sensor (ADNS 9800) and IMU (LIMR051). Similar to a mouse, a signal processor analyzes the change in position by comparing images of the surface as the device moves across the wall.
- **IMU (LIMR051)** consists of a three-axis gyroscope and accelerometer pair that allows for orientation awareness, thereby improving the accuracy of location tracking and eliminating the constraint of parallel orientation with the floor.

### Software Design
- **A Python script running on the Raspberry Pi** reads signal amplitude from the RF sensor using the Walabot API, and assigns a material type based on the amplitude.
- **Simultaneously, the Arduino Pro Micro** uses the optical sensor and IMU to track the location of the device on the wall, and sends the location data to the Python script via a serial connection.
- **Material type and location data** are both sent over Bluetooth to the Android device.
- **Android device receives location data and material type** and marks the material type at the specified location on a picture of the wall.

### Mobile Application
- **The WallHack mobile application** was designed and programed with Android Studio, using Java for functional programming and XML for layout design.
- **Utilizing the Android Camera API** and the Yalantis Ucrop image cropping API, the user can take a picture of the wall and crop it to include only the area they are going to scan.
- **The application receives both material type and location data from the socket, parses them, and uses the Android Canvas API to draw the respective texture on the picture of the wall, as seen in Figure 5.**

### Conclusion
WallHack is projected to cost 50% less than competing products, while offering an improved feature set. The cost savings, along with the ability to generate an accurate depiction of the in-wall infrastructure will aid professionals and DIY enthusiasts save money, plan efficiently, and avoid potential project hazards. Furthermore, consumers can share mappings with contractors and inspectors, streamlining the process of home improvement.

**Ethics Statement:** All results from the WallHack should be tested and verified with other commercial wall scanning devices before drilling or cutting into any scanned wall surfaces.