Utilizing Smartphone Magnetometers for Magnetic Field Tracking and Signal Processing in the Context of Biomedical Engineering

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*Abstract*— This paper investigates the efficacy of smartphone magnetometers for magnetic field recording and analysis using signal processing techniques. Through experimental calibrations and signal processing, we were able to determine smartphone positions within magnetic fields by analyzing readings from a smartphone, providing insights into the physics of magnetism, sensor calibration procedures and signal processing methodologies. [write the results of the experiment, that it is accurate etc.]

Keywords— Magnetism, Helmholtz, spiral coil, signal processing, magnetometer

# Introduction

This paper explores the use of a smartphone’s magnetometer to capture magnetic field data, which is subsequently analysed using advanced signal processing techniques in Python and MATLAB. By leveraging the high precision of modern smartphone devices, we aim to prove that data obtained from such smart devices can be effectively used for signal processing tasks, yielding useful results that aid both research and industry.

Magnetic tracking plays a significant role in biomedical engineering, as this method can be applied in areas such as surgical navigation, where the precise location of instruments is crucial to the success and safety of different clinical procedures. To explore magnetic tracking from a research perspective, a certain level of knowledge in magnetism is necessary, as well as comprehensive knowledge in signal processing and sensor behaviours.

In our experiments, various magnetic layouts were used to locate and calibrate the smartphone magnetometer, culminating in the placement of the smartphone inside a magnetic field grid. Through these calibrations and processing of the resulting signal data, we aimed to accurately calculate the location of the smartphone. The following sections of this paper delve into magnetism, different calibration methods, signal processing techniques, the results of the calculation, and the implications of our experiments for the application of magnetic field tracking in the wider field of biomedical engineering.

# Theory

## Principles of magnetism

Understanding the basic principles of magnetism is crucial to the interpretation and the analysis of the measurement data taken from the smartphone’s magnetometer. The magnetic field, also known as a B-field, is a physical field that influences moving electric charges, currents and magnetic materials. It causes a force perpendicular to the velocity of a moving charge and to the magnetic field itself. A permanent magnet’s field pulls on ferromagnetic materials such as iron, and attracts or repels other magnets.

Electromagnetism is the interaction that occurs between electrically charged particles via electromagnetic fields. It is a combination of electrostatics and magnetism, which are two very closely intertwined phenomena. Maxwell’s equations are a set of partial differential equations governing the laws that describe the behaviour of electric and magnetic fields and their interaction with charged particles.

One of the fundamental principles derived from Maxwell's equations is the Biot-Savart law (1) , which establishes a mathematical relationship between electric currents and the magnetic fields they produce. This law precisely quantifies the magnetic field generated by a constant current in a conductor and relates the magnetic field to the magnitude, direction, length, and the proximity of the electric current.

## Sensors Technology

## Localization and Calibration with Helmholtz Coil

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# Conclusion

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