# Background:

## Introduction to Drone Navigation

Drone navigation refers to the process of guiding a drone from one location to another in a safe and efficient manner. Effective navigation is critical for the successful operation of drones and is achieved through a combination of sensors, algorithms, and communication systems.

Importance of Drone Navigation: Drone navigation is important for a number of reasons. Firstly, it ensures the safety of the drone and its surroundings, as accurate navigation is necessary to avoid collisions and other hazards. Secondly, effective navigation is essential for the successful completion of drone missions, whether it be for aerial photography, delivery services, search and rescue, or military operations. Thirdly, efficient navigation can impact the cost-effectiveness and sustainability of drone operations, as accurate navigation can reduce fuel consumption and minimize the need for additional flight time.

Applications of Drone Navigation: Drone navigation has a wide range of applications, including:

Aerial Photography: Drones equipped with high-resolution cameras are used for aerial photography and videography, providing unique perspectives for capturing images and video from the sky.

Delivery Services: Drones are increasingly being used for delivery services, allowing for fast and efficient delivery of goods and packages, particularly in hard-to-reach or remote locations.

Search and Rescue: Drones equipped with thermal cameras, loudspeakers, and other sensors can be used for search and rescue operations, helping to locate missing persons and provide assistance in disaster-stricken areas.

Military Operations: Drones are used by the military for a variety of missions, including reconnaissance, surveillance, and target acquisition.

### Traditional drone navigation methods

Traditional Drone Navigation Methods:

GPS: GPS (Global Positioning System) is a widely used traditional method for drone navigation. GPS uses a network of satellites to determine the position of a drone in real-time. The drone receives signals from multiple satellites and uses this information to calculate its position, velocity, and altitude. GPS is highly accurate, but its use is limited in areas with poor satellite coverage or when the signal is obstructed, such as when flying in urban areas with tall buildings.

Ultrasonic Sensors: Ultrasonic sensors use sound waves to measure the altitude and proximity of the drone to objects in its surroundings. The sensors emit high-frequency sound waves, and the time it takes for the waves to bounce back to the sensor is used to calculate the distance to the object. Ultrasonic sensors are often used in conjunction with other sensors, such as cameras or infrared sensors, to provide a more comprehensive view of the drone's environment.

Computer Vision: Computer vision is a technology that uses cameras and image recognition algorithms to provide real-time navigation information. This technology enables the drone to identify and track objects in its environment and use this information to make decisions about its navigation path. Computer vision can be used for obstacle avoidance, target tracking, and other applications that require the drone to recognize and respond to its surroundings.

#### Limitations and challenges of traditional drone Navigation methods:

Following are some of the challenges and limitations of traditional Drone navigation methods:

GPS: GPS-based navigation is highly accurate, but its use is limited in areas with poor satellite coverage, such as when flying in urban areas with tall buildings. GPS signals can also be disrupted by natural phenomena such as solar flares or interference from other sources. Additionally, GPS does not provide any information about the drone's environment, making it difficult to avoid obstacles or navigate in areas with limited visibility.

Ultrasonic Sensors: Ultrasonic sensors are relatively inexpensive and easy to integrate into drone designs, but they have limited range and can be affected by environmental factors such as wind and temperature changes. Ultrasonic sensors are also susceptible to interference from other sources of sound, such as other ultrasonic sensors or ambient noise.

Computer Vision: Computer vision-based navigation is capable of providing rich information about the drone's environment, but it requires powerful processors and cameras, which can increase the size, weight, and cost of the drone. Additionally, computer vision algorithms are computationally intensive, which can limit the amount of data that can be processed in real-time.

These limitations and challenges demonstrate the need for improved methods for drone navigation. By addressing these issues, it may be possible to develop navigation systems that are more reliable, accurate, and efficient, enabling drones to operate in a wider range of environments and applications.

## Introduction to BCI Technology

Brain-Computer Interface (BCI) technology refers to the direct communication between the human brain and a computer. BCI technology utilizes brain signals, such as electroencephalography (EEG) or magnetoencephalography (MEG), to enable individuals to control computers, devices, or machines directly through their thoughts.

BCI technology has the potential to revolutionize the way we interact with technology, allowing for more natural and intuitive control. BCI systems can range from simple systems that allow individuals to control a cursor on a screen, to more advanced systems that enable individuals to control prosthetic limbs or operate complex machines.

In recent years, BCI technology has been applied in a range of fields, including medicine, gaming, and human-computer interaction. The development of BCI technology is driven by the desire to create new and more efficient ways of communicating with computers, as well as the desire to help individuals with disabilities or other impairments regain their independence.

BCI technology is still in its early stages of development and there are still many challenges that need to be overcome, such as improving the accuracy and reliability of BCI systems, reducing the complexity and cost of BCI systems, and addressing the ethical and social implications of BCI technology. Nevertheless, the potential benefits of BCI technology are enormous and its development is likely to have a major impact on a range of industries and applications in the future.

### Applications of BCI Technology:

Brain-Computer Interface (BCI) technology has a wide range of potential applications, including:

Medical Applications: BCI technology has the potential to revolutionize the field of medicine. BCI systems can be used to help individuals with disabilities, such as spinal cord injuries or neurodegenerative diseases, regain their independence. For example, BCI systems can be used to control prosthetic limbs, wheelchairs, or other assistive devices. BCI technology can also be used for neurofeedback, which is a form of therapy that uses real-time feedback to help individuals change their brain activity patterns to overcome conditions such as anxiety, depression, or chronic pain.

Gaming: BCI technology has the potential to revolutionize the gaming industry by providing a more natural and intuitive way of playing games. BCI systems can be used to control games directly using thoughts, or they can be used to enhance the gaming experience by measuring the player's emotional state and adjusting the game accordingly.

Human-Computer Interaction: BCI technology has the potential to revolutionize the way we interact with computers, allowing for more natural and intuitive control. BCI systems can be used to control computers, devices, or machines directly through thoughts, eliminating the need for traditional input devices such as keyboards, mice, or touchscreens.

Military Operations: BCI technology has potential applications in military operations, allowing for more efficient and effective communication between soldiers and military equipment. For example, BCI systems can be used to control unmanned aerial vehicles (UAVs), unmanned ground vehicles (UGVs), or other military equipment directly through thoughts, reducing the time and effort required to operate the equipment.

Human Augmentation: BCI technology has the potential to augment human abilities, such as enhancing memory, attention, or perception. BCI systems can be used to provide real-time feedback to the user, allowing them to monitor their brain activity and adjust it to achieve better performance.

### How BCI works

Brain-Computer Interface (BCI) technology utilizes electrodes to measure the electrical activity of the brain and algorithms to interpret these signals. Here's a step-by-step explanation of how BCI works:

Measurement of Brain Activity: BCI systems use electrodes placed on the scalp to measure the electrical activity of the brain. The most common type of electrodes used in BCI systems are Electroencephalography (EEG) electrodes, which measure the electrical signals generated by the brain. In some advanced BCI systems, magnetoencephalography (MEG) electrodes may be used to measure the magnetic fields generated by the brain.

Signal Processing: The raw electrical signals measured by the electrodes are processed and filtered to remove noise and artifact. This includes removing signals generated by eye blinks, muscle activity, and other sources of interference. The processed signals are then transformed into a format that can be used by the BCI algorithm.

Algorithm Development: The processed signals are then fed into an algorithm that interprets the signals and maps them to specific actions or commands. The algorithm is developed using machine learning techniques, such as classification, clustering, or regression, to learn the relationship between the signals and the intended actions.

Feedback and Control: The algorithm outputs the interpreted signals, which can be used to control devices or machines directly. For example, a BCI system could be designed to control a cursor on a screen, or it could be used to control a robotic arm or a drone. The BCI system provides feedback to the user, allowing them to monitor their progress and adjust their brain activity to achieve better performance.

## Combining drone navigation and BCI:

The use of Brain computer Interface (BCI) systems offers a way to enhance life quality by providing a different route for communication between the brain and external devices. In order to decipher the user's purpose and subsequently communicate with the outside world, these interface technologies primarily rely on the data stored in brain signals. Electroencephalography (EEG), which involves placing sensors on the user's scalp to monitor neural activity, is the common method for acquiring the neural signal in BCI systems [1]. After being collected, the data is filtered to remove any noise before being digitally processed to find pre-established EEG patterns. In order to send commands to a target application, the identified patterns can subsequently be translated into commands [2].

The absence of comprehensive reports about the construction of a BCI system, from EEG signal acquisition through application control, is another significant hurdle that BCI systems developers commonly encounter. In particular, topics like converting the results of classification algorithms into useful application commands are frequently left out in the literature. As a result, the full implementation faces many difficulties, which suppresses the fundamental benefit of BCI systems—the final control of an application.

The objective of this project is to complete the development of a BCI system that utilizes µ-wave signals from the motor cortex for controlling an application. The design challenges encountered will be analyzed and documented in detail. The system will utilize widely accepted algorithms [1], for filtering and classifying EEG patterns, which are commonly used in BCI. The implementation will be based on the low-cost and open-source EEG headset OpenBCI, with the goal of resolving the mentioned issues. The purpose is to determine the feasibility of using new EEG devices for designing comprehensive BCI systems. The system will be evaluated by controlling a commercially available drone, which will provide a comprehensive evaluation of the system's performance when operating in a highly flexible application.

A drone, which is capable of moving in three dimensions and has highly agile flight capabilities, poses various challenges related to its movement dynamics, to put it simply [2]. Therefore, it is possible to assess the limitations in terms of dynamics and ease of use posed by these systems by constructing a BCI system to handle such targeted applications. The control of simpler devices will become more stable and trustworthy as BCI technology advances and can manage more complex applications, such as a drone.

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