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# Pilot Assistant for Runway Operations

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***Abstract*— The pilot assistance system is an electronic device which guides the pilot in landing or take-off procedures in runways. The system consists of a hardware which records and display all the sensor readings of the flight continuously, communicates with Air Traffic Control(ATC) for real-time runway conditions, landing/take-off information etc. and displays all the information on the pilot's screen in real-time GUI. The system tries to keep a communication link between pilot and ATC throughout the runway procedure. This helps the pilot in making better decisions during landings or take-offs also effectively help in reducing accidents caused by abnormal runway conditions.**

***Keywords*— *Real-time plotting, Wireless sensor network, Sensor fusion, Automatic air traffic control, Runway sensors, Runway automation***

## I. INTRODUCTION

A runway is an area in an airfield which is usually in the shape of rectangle used to takeoff or land airplanes. Usually runways are straight, and rectangular. The air traffic has increased significantly in recent years leading to increased air movements. The weather conditions may not always be favorable for landings or take-offs around the year. Effect of wind, fog, and rain can induce problems like tailwinds, crosswinds, slippery runways, etc.

There is a need for real-time atmospheric condition measurement. The pilot should be alert under the above mentioned conditions. Momentary lapse could lead to catastrophic accidents. This paper illustrates a real-time pilot assistance system which curtails to all the above addressed problems whose orientation can be monitored graphically. We have developed a system which records and displays runway and flight sensor readings in real-time. This paper also examines the automation possible in the field of the airline transportation and flight operations in the future.

The paper is organized as follows. Literature review is done in section II. Proposed system is discussed in section III. Function description is explained in section IV. System flow diagram and Results are presented in section V and VI respectively. Concluding remarks are along with future scope is given in section VII.

## II. LITERATURE REVIEW

Recently, a lot of research have been done in the field of aircraft automation and wireless communication. Some ideas which is related are discussed in the next paragraph.

There have been many proposed ideas that can be used in airplanes like a wireless flight data recorder which records the plane's sensor values in real time and also transmits the same to the ground station [1]. This system helps in recovering the flight data easily after an incident, but it does not help much in helping the pilot take decisions in difficult situations. An assistance system for pilot which get values from different sensors in the plane an issues voice commands to help pilot make decisions [2]. The voice commands are issued by the system after analyzing many conditions and sensors readings. A virtual assistant for pilot which analyze the pilot's perception and provide alerts in real-time [3]. A study on evaluating the on-board pilot assistance system has been conducted during difficult situations where the pilot will need complex planning [4].

## III. PROPOSED SYSTEM

The Figure 1 illustrates the block diagram of the project, Pilot Assistant device, where there are two main blocks, one for the plane (Figure 1(a)) and other for the Air Traffic Controller(Figure 1(b)).

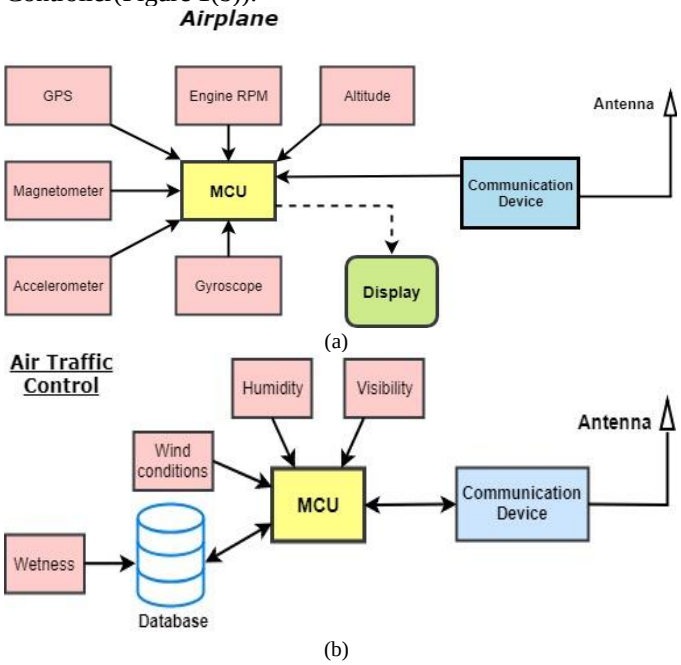


Fig. 1. (a) System needed for airplane (b) System needed for air traffic control(ground)

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The two sub-blocks are as explained below:

a) Airplane
The airplane block consists of MCU, communication module, GPS sensor, Gyroscope, Accelerometer, magnetometer, rpm sensor, altitude sensor and a display screen. These sensors are for analyzing the planes on-board parameters. The readings obtained from the on-board sensors are plotted on the display screen in

b) Air Traffic Control
Air traffic controller consists of a communication module and MCU which communicates with multiple planes at a time. A database is maintained to authenticate the airplane requesting for landing or takeoff and also to take wetness level of runway which cannot be determined by sensors. The database consists of list of planes authenticated for landing or takeoff and also it keeps a list of allocated and free runways.

## IV. FUNCTION DESCRIPTION

The main functions of different blocks in Figure 1 are explained below

(a) Communication Device
The main duty of communication device is to maintain a communication link between pilot and ATC throughout the runway procedure. XBee modules was used for implementing communication device. The XBee module consists of a hardware and a software (Zigbee protocol) needed for communication. XBee devices communicate with each other over the air, sending and receiving wireless signals. They channelize and communicate over the same radio frequency. The XBees are programmed as coordinator and router by giving same PANID. As soon as the plane comes in range of communication, it requests for permission for conducting its runway operation to the ground station.

(b) Microcontroller
The microcontroller is the brain of both the systems, they manage the sensors readings and issue commands for communication. Arduino UNO was used a microcontroller because of its ease of programmability and use of Atmega328P. The board is equipped with 14 digital and 6 analog pins which helps in interfacing different sensors and to implement different protocols. The microcontroller is programmed with algorithms needed for communication and managing the sensor network.

(c) Database
The database keeps the list of authenticated airplanes and a list of occupied runways. It also has information like wetness on runway, visibility which are fed beforehand and should be kept on updating as the conditions change. The database helps in authenticating airplanes and also in the process of allocation of runways.

(d) Sensor Modules
The sensor modules senses on-board parameters like engine rpm, altitude and communicate with the microcontroller. Sensors like BMP180, MPU6050, 10DOF are used to obtain the real-time statistical data on monitors of the plane, which can be displayed on the ground stations for acquiring proper landing coordinates.

## V. SYSTEM FLOW DIAGRAM

Figure 2 shows the flow diagram of the system. The plane sensor data is continuously read and plotted on pilot's screen. When the pilot asks for permission to land, he/she sends the plane number for authentication in ground station. ATC receives the data and checks in its database for the flight number. If authenticated, it grants permission for landing or takeoff. ATC checks the runway segments for landing or takeoff and allocates free runway. The allocated coordinates are sent to plane's communication module, the plane's communication module receives the data and prints on pilot's screen. The pilot performs landing or takeoff accordingly and after successful landing or takeoff pilot send success message. The ATC receives the message and frees the allocated runway for next landing or takeoff procedures. The sensor data from the runway are communicated through the ATC to the authenticated airplane.

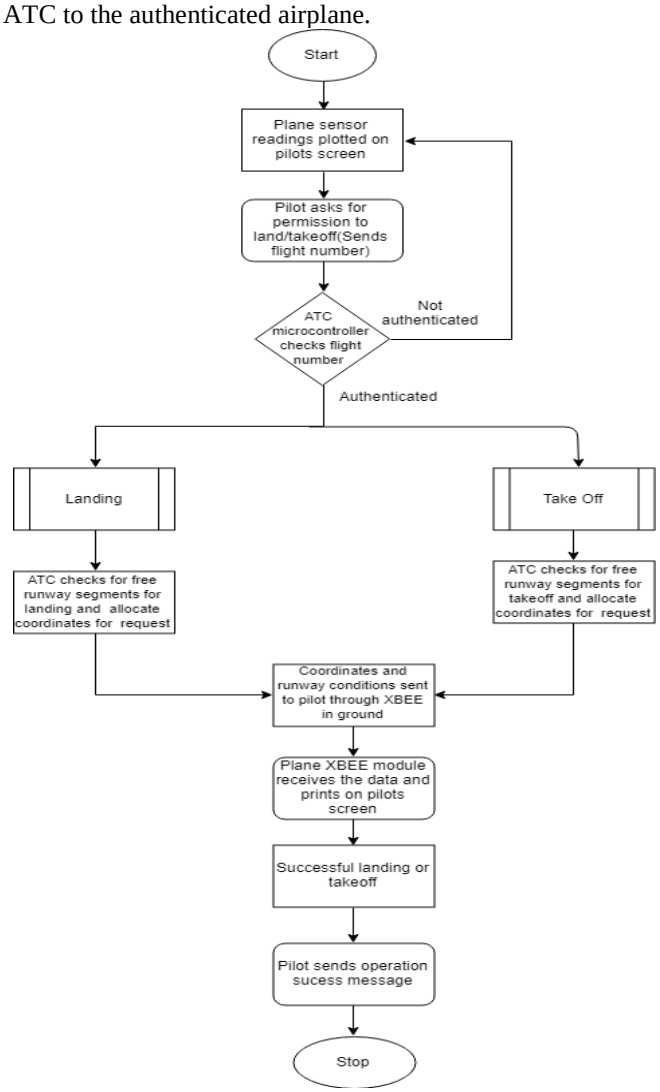


Fig. 2. System flow diagram

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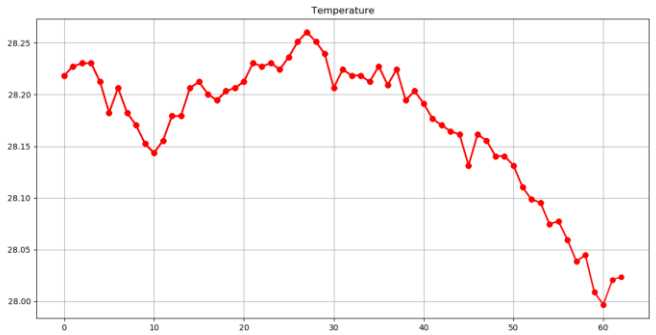
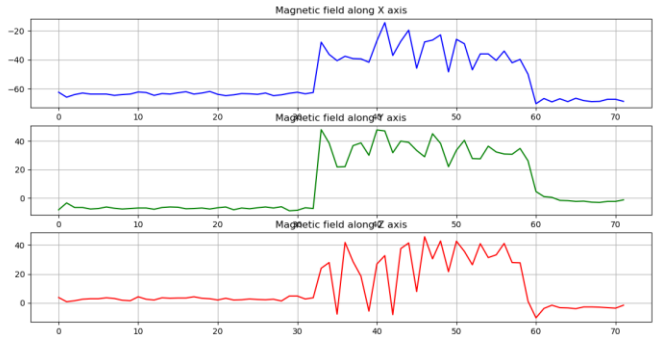
## VI. RESULTS

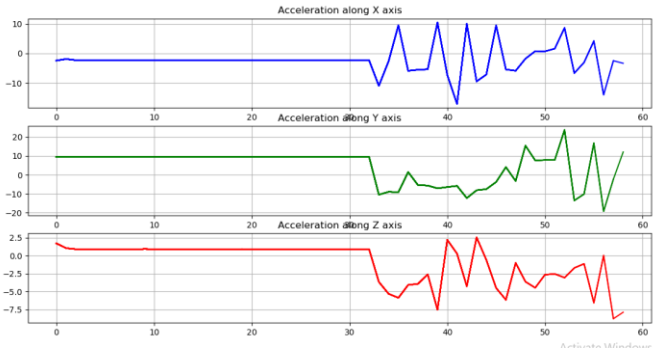
The results are plotted in Python to visualize the data in a simpler way. The plots are updated as the sensor readings change. Also a real-time visualization of airplanes orientation is implemented in Processing language for better assistance. The plotting is done in pilot's screen along with the display of orientation of airplane in real-time. The orientation is displayed by calculating pitch, roll and yaw from the sensors reading.



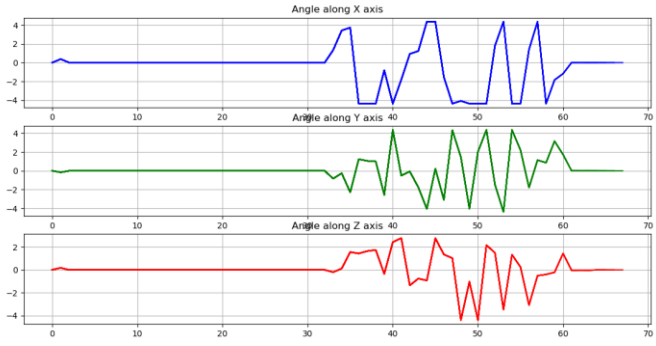

(a)




(b)




(c)




(d)

(e)

Fig. 3. (a) Temperature plot (b) Magnetometer plot (c) Accelerometer plot (d) Gyroscope plot (e) Real-time orientation of plane

The above plots in Fig. 3. (a), (b), (c) and (d) illustrate the real-time sensor data visualized using software for making the data analysis and visualization simpler. The plots are displayed on the screen of the pilot, hence helping the pilot for better decision making. The plots are updated as soon the sensor values reach the microcontroller. Fig. 3. (e) shows the real time 3D model of plane which moves in real time according to the readings of sensors. This helps the pilot in understanding the orientation of the airplane.

## VII. CONCLUSION AND FUTURE SCOPE

The main focus of this work was to assist the pilot in runway procedures using MEMS sensors to provide real-time data on the flight for proper analysis of the flight condition as well as environmental conditions on runway. The flight location coordinates can be recorded and the coordinates for landing and takeoff can be calculated using this real-time data. The use of the XBEE modules for a long distance wireless communication between the ATC and the flight gives reliable connections which is very essential. The reliability of the connection serves an essential aspect in safety. The automation of flight operations on runway opens a gateway to safer and secure travel as pilots are given with real-time data feedback. In future the procedures on runway can be automated by adjusting the wing flaps and controlling the engine RPM combining the data from the ATC and on-board sensors. The plane should automatically adjust its orientation and acceleration on runways by comparing feedback from sensors and data from ATC. The system should compare these two readings to orient, accelerate/decelerate and land/takeoff in specified runway. The sensor readings from plane can be transmitted to ground station in real-time, acting as a wireless black-box. This will eliminate the need for physical black-box in airplanes and will eliminate the difficulty in retrieving black box after accidents. Also faster analyzing can be done since the data is stored in ground databases. The question of wireless data transmission security arises, so a secured system should be developed for the wireless communication that would prevent data breaches.

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