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Integration of Multi-Sensor Environmental and Motion Monitoring Using MXChip AZ3166 for IoT Applications

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ABSTRACT

The rapid growth of the Internet of Things (IoT) has increased the demand for integrated platforms capable of simultaneously monitoring multiple environmental and motion parameters. This study presents the design and implementation of a multi-sensor monitoring system based on the MXChip AZ3166 IoT development board. The system integrates onboard environmental sensors (temperature, humidity, and barometric pressure) and a motion-sensing unit (accelerometer and gyroscope) to enable real-time monitoring. Sensor data are acquired at an average rate of approximately 1 sample per second for environmental parameters and up to 10–50 samples per second for motion sensing. The information is processed locally and made available on a web server hosting platform through structured data formatting via Wi-Fi. Multiple experiments were conducted under similar conditions, and the system was shown to perform near real-time with a mean communication latency of less than 500ms and a stable transmission of data over average network conditions, although the loss of packets was found to be as low as 5%. The system operates with low power consumption, as validated by quantitative measurements presented in this study, which can be used in embedded IoT applications and demonstrates stable performance with continuous monitoring. The proposed architecture offers a small, cost-efficient, and scalable solution to multi-sensor integration, enabling real-time data visualization and remote access. The findings validate the usefulness and success of the MXChip AZ3166 as a general-purpose IoT platform in applications such as smart homes, healthcare monitoring, and industrial applications.

1. INTRODUCTION

The Internet of Things (IoT) has become a major enabler technology that can be used to integrate physical devices, sensors, and clouds to aid intelligent monitoring and decision-making in many fields, including healthcare, smart households, and industrial interfaces [1-5]. The growth of IoT applications has been enormous in fields such as healthcare, agriculture, industrial automation, and smart cities, with the rapid development of low-power embedded systems and cloud services [6-12].

However, despite this rapid growth, most current IoT applications are based on single-sensor architectures, which can provide limited information on complex and dynamic environments. In practice, environmental conditions and physical activities are intrinsically interrelated, and simultaneous observation of various parameters is necessary to arrive at a precise and context-sensitive analysis [13]. This limitation has been overcome by the introduction of multi-sensor systems that fuse information from other modalities of sensations. Nevertheless, current solutions are prone to greater system complexity, high cost, and difficulties in integration, communication, and real-time data processing [14].

To overcome these difficulties, this project will use the MXChip AZ3166 IoT development board as a single platform for multiple sensors. The use of AZ3166 can be explained by the presence of environmental sensors (temperature, humidity, and pressure), an integrated motion-sensing unit (accelerator, gyroscope), and native Wi-Fi connectivity, which simplifies the hardware and allows for easy integration with the cloud. This renders the platform especially appropriate for quick prototyping and deployment scaling of the IoT monitoring systems.

Moreover, the proposed system satisfies the needs of practical applications. For example, smart home systems require constant monitoring of the environment and motion detection for comfort and security, whereas healthcare applications require stable monitoring of environmental conditions and human activity. Safety and performance optimization also ensures that industrial monitoring systems require strong and real-time data acquisition.

The primary asset of this work is the creation of a small, inexpensive, and scalable IoT-based multi-sensor surveillance apparatus that offers a complete information pipeline, including information collection and preprocessing to wireless data transportation and visualization on a cloud platform. In contrast to current methods, which handle separate functionalities, the proposed system provides a single architecture that is easy to deploy but provides reliable real-time operations.

2. RELATED WORK

Recent studies have demonstrated the tremendous development of multi-sensor monitoring using IoT devices. In one study, the environmental status was monitored using an ESP8266 module, with an emphasis on low cost and availability through the cloud. Another study utilized a Raspberry Pi as a real-time motion detector and a temperature sensor for smart home scenarios. Yet another study implemented an Arduino-based system with numerous air quality and humidity sensors, revealing power consumption and wireless stability problems. A fourth study utilized an STM32 microcontroller to monitor industrial environmental measurements with greater sensor precision and network reliability.

The latest paper presented the use of an MXChip AZ3166 for effortless IoT integration and improved data visualization performance, providing further evidence that it is faster to integrate and easier to deploy than any modern IoT monitoring system. Table 1 lists the devices employed in previous initiatives in this domain.

Manthina et al. [15] present a scalable and low-cost IoT-based approach for real-time noise monitoring using mobile nodes (sensor nodes embedded on vehicles) that capture geotagged noise data at one-second intervals. The system uses inexpensive sound sensors calibrated with reference meters in a laboratory environment and different machine learning (ML) techniques. The accuracy generated during lab calibration results is lower in mobile environments, and on-site calibration is performed using reference instruments.

The advancement of 5G, particularly mMTC, has accelerated the growth of IoT systems, where sensors play a critical role [16]. However, their integration with wireless technologies introduces design and performance challenges. This survey provides an overview of wireless sensor nodes, including their architecture, classification, and performance evaluation. It also discusses wireless sensor networks, communication protocols, applications, and key challenges, along with future developments to enhance their capabilities.

The study [17] proposes a combined implementation of IoT and ML for flood management. It is composed of water stations, equipped with radar sensors for overflow detection and repeater sorting, and is capable of transmitting all kinds of data continuously, and siren stations into which various environmental sensors are integrated. Following data collection, we employed a 1D convolutional neural network (CNN) for spatial relations and the multivariate long short-term memory (M-LSTM) to capture temporal dependencies. The proposed approach outperforms state-of-the-art methods with a mean squared error (MSE) of 0.018. The procedure will test ML algorithms and optimize for better sensor data to better manage floods.

The study [18] is structured to support three major system implementation issues: the development of an affordable, miniaturized multisensor system; methods to discriminate between faulty and non-faulty models for accurate detection; and machine-learning methodology for air quality classification and identification. The prototype integrates sensors for diverse pollutants and achieves cost-effective monitoring, even in outdoor environments; more than 30 K data points can be collected every month.

The study [19] evaluates the quality of IoT sensor data within a peatland monitoring network and emphasizes data quality as a catalyst for fostering innovation that facilitates the adoption of IoT. Challenges about data quality are identified, both in terms of sensor deployment and signal acquisition: location of sensors, calibration of used systems, validity of collected information, external interference, and treatment for gaps. This research problem is aligned with methods for improving data quality through advanced calibration schemes, validation algorithms, ML schemes, and data fusion schemes.

Table 1. The list of relevant research papers

Authors	**Microcontroller Unit**	**Sensors**	**Comm.**	**Cloud**	**Real-Time**	**Power**	**Data Fusion**	**Key Contribution**
Djordjevic and Dankovic [20]	PIC18F45K22	Env	GSM	Web	Low	Medium	No	Basic monitoring
Shahadat et al. [21]	ESP8266	Env	Wi-Fi	Web	Medium	Low	No	Low-cost
Rao et al. [22]	Arduino + ESP8266	Multi	Wi-Fi	Web	Medium	Medium	Limited	Multi-sensor
Bella et al. [23]	ESP8266	Env	Wi-Fi	Web	Medium	Low	No	Weather system
Sámano-Ortega et al. [24]	ESP8266	Env + Energy	Wi-Fi	ThingSpeak	Medium	Medium	Limited	IoT platform
Kristiani et al. [25]	ESP32	Multi	GSM	Cloud	High	High	Yes	Complex system
This work	AZ3166	Env + Motion	Wi-Fi	Web Server	High	Low	Yes	Integrated platform

3. SYSTEM DESIGN AND ARCHITECTURE

The system offers multi-sensor monitoring with one IoT platform using the MXChip AZ3166 development kit. The architecture is designed to have both hardware sensors to detect the environment and motion and software modules to include data collection, processing, transmission, and visualization to the cloud by hosting a web server. The system design is sized and low-power efficient and supports wireless communications with a high degree of robustness, which allows it to be used in a multitude of IoT applications.

3.1 Overview of MXChip AZ3166 platform

The MXChip AZ3166 shown in Figure 1 is a prototyping kit for an IoT device that uses the ARM Cortex-M4 microcontroller. It has built-in Wi-Fi (IEEE 802.11 b/g/n) for easy connection to cloud platforms and over-the-air updates, simplifying deployment. The board features a 128 × 64 Organic Light-Emitting Diode (OLED) display, user-programmable buttons, and some built-in sensors (environmental and motion), and is available in six unique forms for all visual learners. With support for development and cloud platforms, including the Arduino IDE, Visual Studio Code, Microsoft Azure IoT, and web server hosting, developers are provided with a variety of options to build familiar applications on top. The main properties of this kit are listed in Table 2.

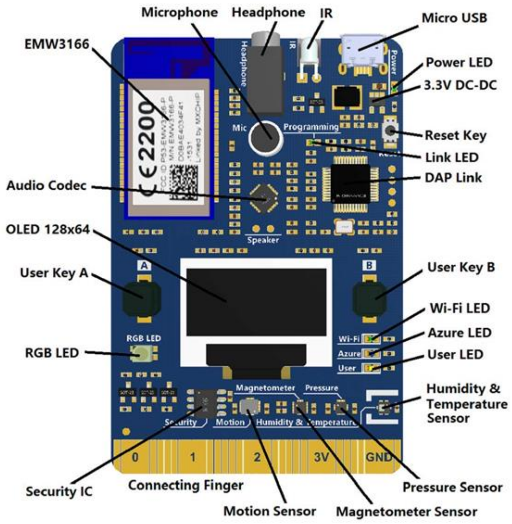


Figure 1. The MXChip AZ3166 development board

3.2 Integrated environmental and motion sensors

The AZ3166 incorporates multiple onboard sensors that enable simultaneous measurement of environmental and motion parameters.

3.2.1 Environmental sensors

1. **LPS22HB barometer:** The LPS22HB in Figure 2 is a precision Micro-Electro-Mechanical Systems (MEMS) barometric pressure sensor that is widely used in environmental monitoring and IoT applications. The absolute atmospheric pressure can be measured with a very good accuracy of approximately ±1 hPa and temperature of ±1.5 °C. It uses the I²C or SPI communication protocol, which is supported by many popular microcontrollers, such as Arduino and Raspberry Pi. The compact form factor, low power consumption, high performance, and repeatability of LPS22HB are designed to be integrated in the foreground of various wearable devices, such as weather forecasts, altitude measurement, indoor climate control, and multi-sensor environmental monitoring systems.

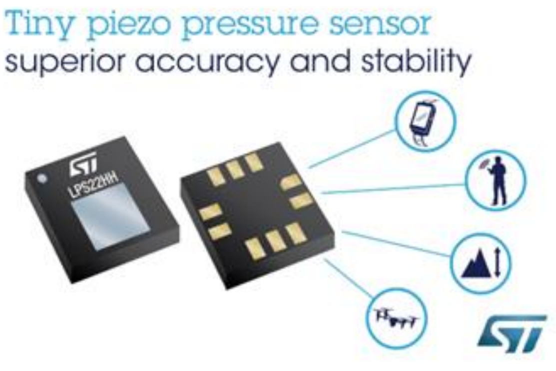


Figure 2. The LPS22HB sensor
Source: https://siliconsemiconductor.net/article/106013/Tiny_MEMS.

Table 2. The properties of the MXChip AZ3166 kit

Category	Specification
Microcontroller	ARM Cortex-M4 32-bit RISC core, 100 MHz clock speed
Flash Memory	1 MB internal flash
SRAM	256 KB internal SRAM
Wireless Connectivity	Wi-Fi IEEE 802.11 b/g/n (2.4 GHz), built-in antenna
Environmental Sensors	- **LPS22HB**: Barometric pressure (260–1260 hPa, ±1 hPa accuracy) - **HTS221**: Temperature (–40 °C to +120 °C, ±0.5 °C accuracy), Humidity (0–100% RH, ±3.5% RH accuracy)
Motion Sensor	- **LSM6DSL**: 3-axis accelerometer (±2/±4/±8/±16 g) 3-axis gyroscope (±125 to ±2000 dps)
Audio	- MP34DT01 digital MEMS microphone
User Interface	- 2 user-programmable buttons - 1 reset button - 4 user LEDs
Power Supply	5 V via micro USB (supports external power source)

Note: Static Random-Access Memory (SRAM), Relative Humidity (RH), Micro-Electro-Mechanical Systems (MEMS), Light-Emitting Diode (LED), Universal Serial Bus (USB)

Figure 3. The HTS221 sensor
Source: https://rutronik-tec.com/stmicroelectronics-hts221/.

2. **HTS221 humidity and temperature sensor:** The HTS221 sensor, illustrated in Figure 3, is a factory-calibrated dual-digital humidity and temperature sensor. It provides 0%–100% relative humidity (RH) readings with ±3.5% RH accuracy and -40 to +120 °C temperature readings with ±0.5 °C accuracy. The sensor communicates over I²C or SPI interfaces; therefore, it is compatible with a wide variety of microcontrollers, such as the MXChip AZ3166. The key benefits are its small size, low power consumption, and stable output under a wide range of conditions, from factory settings to the field. Optimal for environmental monitoring applications utilizing smartphones, IoT-based multi-sensor devices, and climate control systems.

3.2.2 Motion sensors (LSM6DSL IMU)

The LSM6DSL, illustrated in Figure 4, is a low-power 6-axis IMU with numerous features that would enable our customers to make the most out of innovative embedded system designs with a very small footprint and long battery life. It can perform motion tracking, gesture recognition, and vibration detection; it has linear acceleration (±2/±4/±8/±16 g) and angular velocity (up to ±125/s to ±2000 o/s). The sensor has I^2C and SPI connectivity and is, thus, simple to interface with microcontrollers, including the MXChip AZ3166. It is also best in IOT because of low power, high sensitivity, and the data must be output fast in specific motion and orientation data.

By pairing these sensor devices, one can obtain a complete dataset, which is therefore suitable for IoT applications, not only in environmental monitoring but also in very specific physical activity tracking. The interdisciplinary process has led to increased flexibility of systems to enhance decision-making, predictive analysis, and intelligent automation in most fields of application, such as smart homes, healthcare applications, and industrial processes.

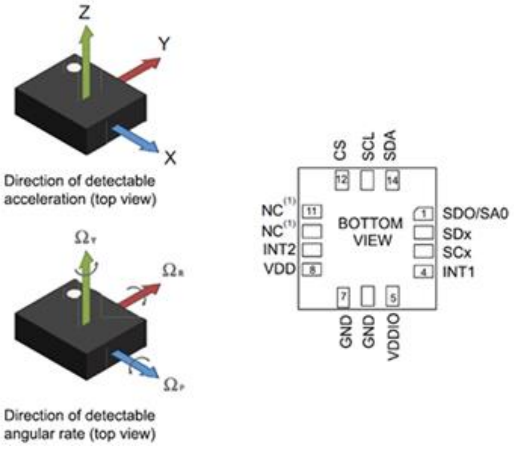


Figure 4. The LSM6DSL motion sensors
Source: https://www.st.com/en/mems-and-sensors/lsm6dsl.html.

3.3 Hardware and software architecture

The hardware and software components are arranged in a layered architecture, as shown in the conceptual block diagram in Figure 5. This architecture has four main layers: hardware, firmware, application, and cloud (web server hosting). This paragraph will go into more detail about each layer.

(1) **Hardware Layer:**

The microcontroller, sensors, OLED display, and Wi-Fi board were all mounted on the MXChip AZ3166 board. USB or external power options allow the unit to be a portable solution.

(2) **Firmware Layer:**

Sensor drivers and middleware libraries are provided to initialize, configure, and read data from sensors in the vehicle. The firmware also handles Wi-Fi communication, wireless transmission to cloud storage, and data formatting.

(3) **Application Layer:**

The sensor fine-tuning results were generated using local processing in a microcontroller to obtain optimal and noise-free results. Necessary parameters, such as temperature, humidity, pressure, acceleration, and angular velocity, were gathered and preprocessed for transmission.

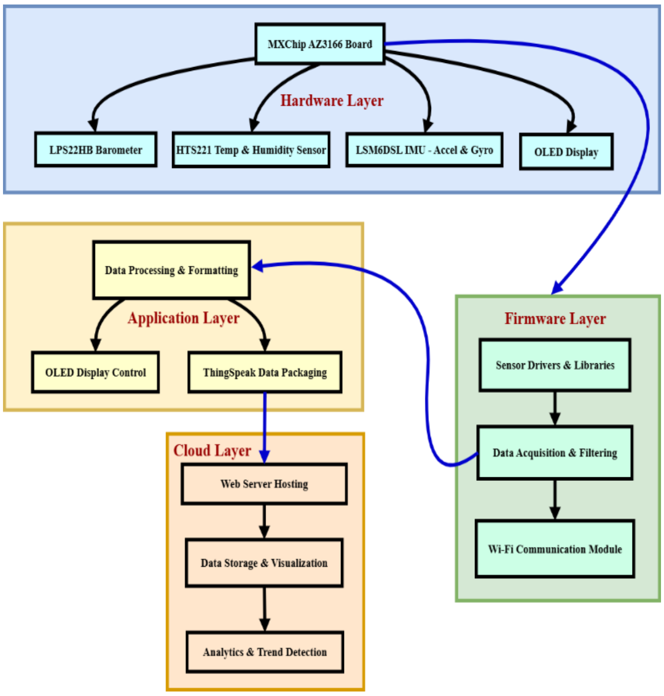


Figure 5. Layered system architecture: Block diagram

(4) **Cloud Layer (Web Server Hosting):**

The proposed multi-sensor IoT system was implemented using the MXChip AZ3166 development platform with a well-defined software and communication framework. The system was developed using the Arduino IDE and Visual Studio Code, utilizing the official AZ3166 libraries for sensor interfacing and Wi-Fi connectivity.

Sensor data were acquired through the I²C interface from the onboard sensors (HTS221, LPS22HB, and LSM6DSL). The environmental sensors were configured with a sampling rate of approximately 1 Hz, whereas the IMU sensor operated at higher rates (10–50 Hz) to capture motion dynamics. A simple scheduling mechanism was implemented to handle different sensor sampling rates efficiently.

The data were gathered and structured as pairs of key-values and then transmitted. A lightweight HTTP-based communication protocol was used to send data packets over Wi-Fi to a web server hosting platform. The sensor readings, such as temperature, humidity, pressure, acceleration, and angular velocity, were provided in each packet with a timestamp.

Cloud deployment was based on a custom web server hosting service, in which the received data were saved and viewed via a web interface. The system enables remote monitoring and basic data analysis through a channel-based data structure that supports real-time data updates.

4. IMPLEMENTATION AND DATA ACQUISITION

The implementation stage will entail the setup of the MXChip AZ3166 platform to be used in sensor data capture, wireless sensor, and visualization on the cloud. The remainder of this paper describes sensor connection and configuration, data collection and processing, and communication with the web server where the cloud platform is hosted.

4.1 Sensor interfacing and configuration

The AZ3166 includes in-board environmental and motion sensors (patented sniffers) to provide communication with the microcontroller chip via an I^2C bus. It is not dependent on any external hardware, as the system complexity is low and system mobility is high. Introduction of the sensor was done through the following steps.

1. **Initialization:** Sensor drivers (except those belonging to the official AZ3166 libraries) were added to communicate with the LPS22HB, HTS221, and LSM6DSL.
2. **Calibration:** Basic calibration procedures were performed to improve the measurements, including zero-offset calibration of the accelerometer and gyroscope.
3. **Sampling Settings:** For environmental sensors, the sampling interval was set to the rate based on the data type (e.g., one sample per second), and for the IMU, it was interpolated to encompass motion dynamics.
4. **Display Output:** An integrated OLED touch screen displays real-time sensor data with instant feedback during system testing.

This arrangement enables a strong estimation of the environmental and motion parameters using additional sensor modules.

4.2 Data collection and processing workflow

After configuration, the system actively gathers raw sensor data, and local processing is performed before the data are transmitted to the cloud. The workflow is arranged in the following manner:

1. **Acquisition:** Environmental sensors provide temperature, humidity, and pressure data, whereas an IMU provides acceleration and angular velocity data.
2. **Filtering:** Noisy accelerometer and gyroscope data were smoothed using simple filters (moving average filters).
3. **Formatting:** The sensor values obtained were transformed into units that are easy for humans to interpret (°C, %RH, hPa, m/s², and °/s).
4. **Data Packaging:** The sensor values were combined as key-value pairs that could be used for web server hosting channel fields.
5. **Local Monitoring:** The selected readings were presented on an OLED screen, and the user was required to confirm them.

This processing workflow reduces data transmission errors, and only relevant, clean data is transmitted to the cloud.

4.3 The flowchart of the proposed IoT system

As shown in Figure 6, the program flow describes the operation of the MXChip AZ3166-based IoT monitor. The program initializes the MXChip AZ3166 board and on-board sensors, such as pressure, temperature, and humidity, via LPS22HB and HTS221, while enabling its first set of capabilities (specific to each wearable's range using LSM6DSL). After starting, environmental data (e.g., temperature, humidity, and pressure) and movement data (e.g., parallel acceleration and angular velocity) can be read at any time.

The recorded sensor information was further preprocessed to guarantee its correctness and consistency for any post-analysis. Once processed, the outcomes were displayed on an OLED screen for local monitoring and were also sent to a web server hosting platform for visualization. The program subsequently entered an infinite loop that encompassed data collection, processing, and transmission to maintain real-time monitoring and system authenticity.

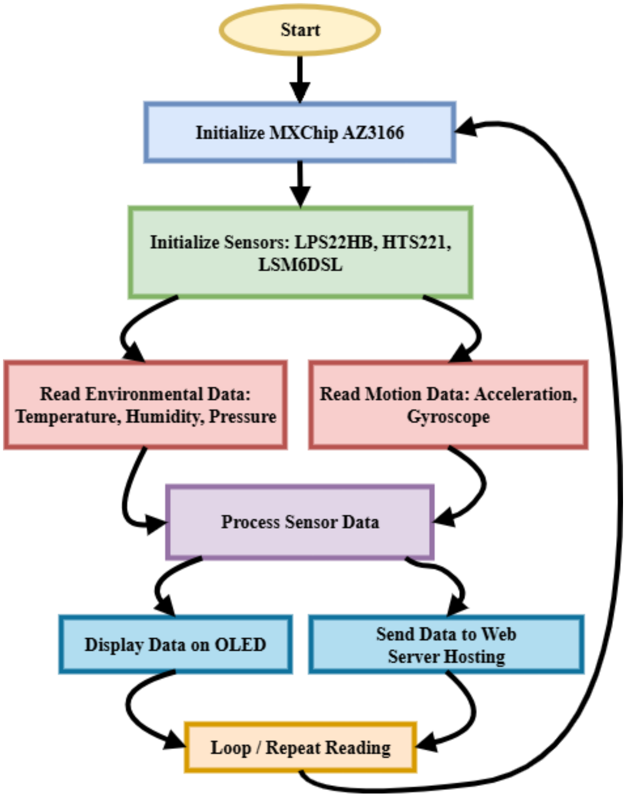


Figure 6. Program flowchart of the MXChip AZ3166-based IoT monitoring system

5. RESULTS AND DISCUSSION

The effectiveness of the proposed multi-sensor IoT monitoring system was evaluated through a series of real-time experiments under typical indoor Wi-Fi conditions. To enhance the quality of the assessment, several measurements were performed and compared statistically. Motion data (acceleration and angular velocity) were acquired at rates of 10 to 50 samples per second, depending on the application requirements, and the system continuously recorded environmental data (temperature, humidity, and pressure) at an average rate of approximately 1 sample per second.

A quantitative assessment was performed to supplement the visual results presented in Figures 7 and 8. When the network was not unstable, the end-to-end communication latency between the cloud and the acquisition of the data and the visualization was between 200 and 500 ms. It had a good data transmission, and when the system was operating equally, there was not more than a 5 percent loss in data packets. It was observed that the data upload rate to the environment parameters was approximately one update per second, and the motion data were being processed at the local level; only a few were sent to make the best use of the bandwidth.

(a) AZ3166 at starting (b) The results of LPS22HB

(c) The results of HTS221 (d) The results of LSM6DSL

Figure 7. Sensor readings displayed on Organic Light-Emitting Diode (OLED)

Table 3 shows several sensor measurements they obtained under the same operating conditions to ensure that the measurements of the system were repeatable and reliable. The statistics indicate that there is uniform behavior in all the parameters, and deviations are blamed on environmental and sensor noise.

Table 3. Sample sensor readings under similar conditions

Temp. (°C)	Humidity (%)	Pressure (hPa)	Accelerometer (AX, AY, AZ)	Gyroscope (GX, GY, GZ)
30.2	31.2	1005.86	(3, -5, 1046)	(-1260, 350, 840)
30	38.2	1006.47	(0, -11, 1044)	(-1190, 280, 910)
30.15	33.5	1006.1	(2, -6, 1045)	(-1230, 320, 870)
30.05	35.1	1006.3	(1, -8, 1043)	(-1210, 300, 890)
30.25	32.8	1005.95	(4, -4, 1047)	(-1270, 360, 830)
30.1	36.4	1006.55	(0, -9, 1042)	(-1180, 270, 920)
30.18	34.2	1006.2	(2, -7, 1045)	(-1220, 310, 880)
30.08	37	1006.6	(1, -10, 1043)	(-1170, 260, 930)
30.22	32.1	1005.9	(3, -5, 1046)	(-1250, 340, 850)
30.12	35.8	1006.4	(1, -8, 1044)	(-1200, 290, 900)

A summary of the statistical analysis of the collected data is presented in Table 4, which shows the mean values, standard deviations, and confidence intervals. The standard deviation in temperature and pressure is low, indicating that the system is very stable, and the standard deviation in humidity is medium, representing changes in the natural environment.

Table 4. Statistical analysis of sensor measurements

Parameter	Mean	Std. Deviation	95% Confidence Interval
Temperature (°C)	30.135	0.08	±0.050
Humidity (%)	34.53	2.39	±1.48
Pressure (hPa)	1006.23	0.25	±0.16

5.1 System results on Organic Light-Emitting Diode

A table of sensor values of the onboard sensors of the MXChip AZ3166 (temperature, humidity: HTS221, barometric pressure: LPS22HB, and motion detection: LSM6DSL) is provided in Figure 7 under different operating conditions. These were readings on the OLED screen, which presented real-time information on how the system worked.

The OLED display ensures that the system is responsive, and the sensor values are consistent. Minor variations observed in the sensor outputs reflect normal environmental fluctuations and measurement noise, which were reduced using a moving average filtering technique. These results provide qualitative validation of the system functionality at the device level.

5.2 System results on the web server and smartphone

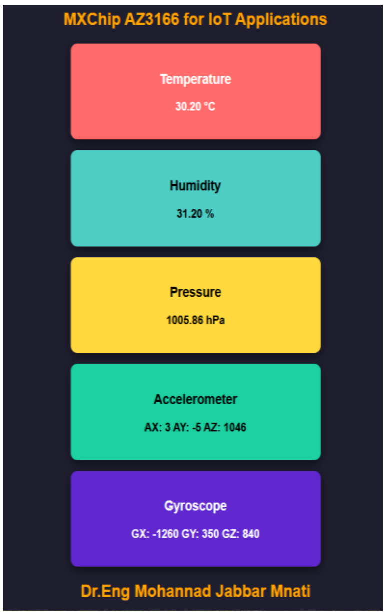
The sensor readings were sent to the web server platform, as shown in Figure 8, which allows monitoring remotely using the web and mobile interface. The system exhibited stable real-time visualization with a constant refresh rate and no notable delays in a typical Wi-Fi setup.

The responsiveness of the system and sensor congruence of the system were confirmed in the OLED visualization. The sensor outputs exhibited minor fluctuations owing to normal fluctuations in the surroundings and measurement noise, which were minimized by applying the moving average filtering method. These outcomes are qualitative confirmations of system functionality at the device level.

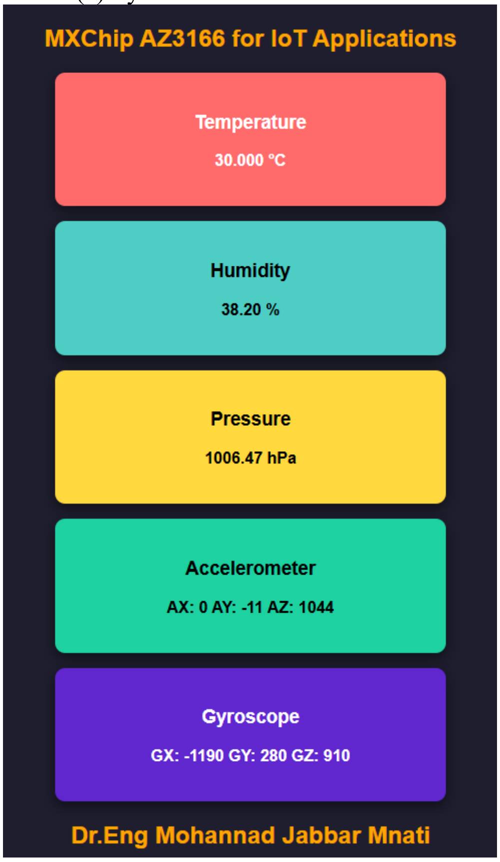
5.3 Sensor accuracy and system stability

The onboard sensors (HTS221, LPS22HB, and LSM6DSL) performed well according to the datasheet requirements. The temperature, humidity, and pressure were all within ±0.5 °C, ±3.5% RH, and ±1 hPa, respectively. The filtering resulted in the data of the motion being stable, which enhanced the reliability of the signals.

The system was also tested to operate for extended periods (several hours) and exhibited consistent functioning without system crashes or communication loss. Nevertheless, sustained Wi-Fi transmission increased power consumption, which may be a constraint to the long-term use of battery-powered devices.


MXChip AZ3166 for IoT Applications
Temperature
30.20 °C
Humidity
31.20 %
Pressure
1005.86 hPa
Accelerometer
AX: 3 AY: -5 AZ: 1046
Gyroscope
GX: -1260 GY: 350 GZ: 840
Dr.Eng Mohannad Jabbar Mnati

(a) System results on the website


MXChip AZ3166 for IoT Applications
Temperature
30.000 °C
Humidity
38.20 %
Pressure
1006.47 hPa
Accelerometer
AX: 0 AY: -11 AZ: 1044
Gyroscope
GX: -1190 GY: 280 GZ: 910
Dr.Eng Mohannad Jabbar Mnati

(b) System results on smartphone applications

Figure 8. Sensor readings are monitored remotely via a web server and smartphones

Table 5 lists the estimated power consumption of the system components according to the datasheet specifications and normal operating conditions. The power consumption of the MXChip AZ3166 board is not constant and depends on Wi-Fi usage and the load on the processor. Therefore, an estimation value of 70 mA was used. The environmental and motion sensors (LPS22HB, HTS221, and LSM6DSL) have very low power consumption in microamps, and these are a subject of much overall system efficiency.

Table 5. Power consumption of system components (AZ3166-based system)

Component	Voltage (V)	Current (mA)	Power (mW)
MXChip AZ3166 Board	5	70	350
LPS22HB Barometer	3.3	0.003	≈ 0.01
HTS221 Temperature & Humidity	3.3	0.002	0.0066
LSM6DSL IMU (Accel + Gyro)	3.3	0.003	≈ 0.01
Total Estimated Power	—	—	**≈ 351**

The overall power consumption is about 351 mW, which proves that the offered system has a low power consumption and can be used in the implementation of energy-saving IoT solutions. It is necessary to note that the real power consumption can be varied in accordance with the Wi-Fi activity, the sampling rate, and the system workload.

5.4 Limitations and challenges

Although the system performed well in general monitoring tasks, several limitations were identified:

1. **Sensor Accuracy:** Suitable for general-purpose monitoring but not for high-precision medical or industrial applications.
2. **Wi-Fi Dependency:** System performance depends on network stability, and data loss is observed under weak connectivity conditions.
3. **Power Consumption:** Continuous operation over Wi-Fi increases the energy consumption.
4. **Scalability:** The current implementation is optimized for single-node deployment and may require enhancements in multi-node systems.

Table 6. The list of performance metrics

Metric	Value
Environmental Sampling Rate	~1 Hz
Motion Sampling Rate	10–50 Hz
End-to-End Latency	200–500 ms
Packet Loss	< 5%
Data Upload Rate	~1 update/sec
Temperature Accuracy	±0.5 °C
Humidity Accuracy	±3.5% RH
Pressure Accuracy	±1 hPa

5.5 Summary of key performance metrics

Table 6 lists the key performance indicators of the proposed system, including the sampling rates, communication latency, data transmission reliability, and sensor accuracy, which quantitatively analyze the system performance.

6. CONCLUSIONS

The design and implementation of a multi-sensor Intelligent Building Monitoring (IBM) monitoring system have been introduced in the paper, which has been developed using the MXChip AZ3166 platform. It is possible to coordinate environmental (temperature, humidity, and pressure) and motion (acceleration and angular velocity) monitoring in the same architecture and achieve real-time data collection, processing, and visualization in the cloud using the proposed system.

It was experimentally demonstrated that under typical Wi-Fi conditions and a data acquisition rate of 1 to 50 Hz for motion data and 1 Hz for environmental parameters, the system was stable at a real-time performance rate. When the network was not under stress, the communication latency was below 500 ms, and the packet loss was not more than 5%. These results demonstrate that the system suggested is convenient for use in continuous monitoring.

Despite these advantages, the proposed system has several restrictions. The system requires uninterrupted Wi-Fi connectivity, which may restrict its application in poor networks. In addition, high power consumption may limit battery life, and onboard sensors may be sufficient for general monitoring, but are not suitable for fine medical or industrial-grade applications.

The next generation will consider expanding the system for use in multi-node systems, optimizing power consumption to support the long-term functioning of the system, and implementing superior data processing and edge-based intelligence approaches that can increase the accuracy and self-sufficiency of the system. These developments will also make the proposed system more applicable to demanding real-life IoT scenarios.

The findings reveal that the system is stable in performance when operated continuously. The statistical analysis proves that the key environmental parameters are not highly variable, indicating that the sensors will behave reliably. Moreover, the power consumption analysis confirms the effectiveness of the system and its suitability for long-term IoT implementations.

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