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Theme

Manufacturing and production of a smart scale with android app

Publicly defended on: 02/06/2025 before the jury composed of :

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Dedication

I wholeheartedly dedicate this work to my beloved family, whose unwavering love, support, and encouragement have been the cornerstone of my journey and success.

To my dear parents, whose sacrifices, patience, and guidance have shaped me into the person I am today—your faith in me has been my greatest source of strength and motivation through every challenge.

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This achievement is not mine alone but belongs to all of you who stood by me, believed in my dreams, and provided me with a safe and loving environment to grow and learn. Thank you for being my foundation and inspiration. I dedicate this work to you with all my heart.

Zine mohamed elhabibe

Dedication

With deep love and gratitude, I dedicate this work to my beloved family, who have always been my greatest support and refuge.

To my dear parents, who have given their all for me, whose encouragement and prayers have been my strongest motivation throughout this journey.

To my brothers and sisters, whose presence has brought joy and inspiration, making the challenges easier to overcome.

To every member of my family, thank you for your patience, unconditional love, and unwavering support.

You planted hope in my heart and filled my life with happiness—this achievement is the fruit of your sacrifices and encouragement.

This work is for you, and through you, I realize my dreams.

Sandali abderrezak

Abstract

Manufacturing and Production of an Android App Smart Scale

The smart scale was designed and developed to function in tandem with an Android application, providing real-time readings and additional functionality to users. The production process focused on precision, user-friendliness, and mobile compatibility. The scale uses sensors connected to a microcontroller (e.g., Arduino), which transmits data wirelessly to the Android app. The application allows for weight tracking, saving records, and receiving alerts or tips in different languages, including Arabic and English. The smart scale aims to help monitor health by providing a simple-to-use, available device that can work efficiently even in remote areas and assist in overall health management.

Key words: Scale,smart,sensors,Android

Résumé

Fabrication et production d'une balance connectée pour application Android

Cette balance connectée a été conçue et développée pour fonctionner en tandem avec une application Android, fournissant des relevés en temps réel et des fonctionnalités supplémentaires aux utilisateurs. Le processus de production a mis l'accent sur la précision, la convivialité et la compatibilité mobile. La balance utilise des capteurs connectés à un microcontrôleur (par exemple, Arduino), qui transmet les données sans fil à l'application Android. L'application permet le suivi du poids, l'enregistrement des données et la réception d'alertes ou de conseils en différentes langues, dont l'arabe et l'anglais. Cette balance connectée vise à faciliter le suivi de la santé en proposant un appareil simple d'utilisation et accessible, efficace même dans les zones reculées et contribuant à la gestion globale de la santé.

Mots cles : Balance, intelligentes, capteurs,Android

ملخص

تمثل المقاييس الذكية تحولاً نموذجياً في أنظمة مراقبة الصحة الشخصية والقياس الصناعي، حيث تستخدم أحدث التقنيات لتقديم بيانات دقيقة في الوقت الفعلي وتجربة مستخدم محسنة.تركز هذه الدراسة على تصميم وإنتاج نظام مقياس ذكي يعمل على تطبيق Android. يجمع النظام بين التقاط البيانات تلقائيًا والمراقبة والتحكم عن بعد عبر تطبيق سهل الاستخدام يدعم اللغتين العربية والإنجليزية بالإضافة إلى لغات أخرى حسب الحاجة. يمكن استخدام الميزان الذكي لقياس الوزن ومؤشر كتلة الجسم (BMI) ومؤشرات صحية أخرى أو وزن الأشياء، اعتمادًا على الاستخدام (شخصي أو صناعي). ويقوم أيضًا بمزامنة البيانات على الفور مع الهواتف الذكية عبر البلوتوث أو Wi-Fi، مما يسمح للمستخدمين بتخزين البيانات وتتبعها وتحليلها على المدى الطويل. ويعتمد النظام على متحكمات Arduino لإدارة المستشعرات بدقة ومعالجة البيانات بكفاءة. بالإضافة إلى ذلك، يوفر التطبيق تذكيرات بحد الوزن، ويسجل البيانات تلقائيًا، ويتميز بالتحكم باللمس والصوت. يتناول هذا المشروع الحاجة إلى

أجهزة ذكية منخفضة التكلفة ومتعددة اللغات وموفرة للطاقة، مما يوفر حلاً عمليًا للاستخدام المنزلي والصناعي.

الكلمات الرئيسية : ميزان ذكي ,أجهزة استشعار اندرويد

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List of abbreviation

APIs	Application Programming Interfaces
EEPROM	Electrically Erasable Programmable Read-Only Memory
ESP32	Espressif Systems ESP32 Microcontroller
GPIO	General Purpose Input/Output
HX711	HX711 24-bit Analog-to-Digital Converter for Weigh Scales
HTTP	HyperText Transfer Protocol
IoT	Internet of Things
IDE	Integrated Development Environment
JSON	Java Script Object Notation
Load Cell	Load Cell Sensor (or Strain Gauge Load Cell)
MIT App Inventor	Massachusetts Institute of Technology App Inventor
MCU	Microcontroller Unit
NTP	Network Time Protocol
REST	Representational State Transfer
SCK	Serial Clock
ToF	Time of Flight
Wi-Fi	Wireless Fidelity

General Introduction

In today's era of digital health and fitness, smart scales have emerged as essential devices for tracking body composition metrics such as weight, body fat percentage, muscle mass, BMI, and more. These devices sync with mobile applications, allowing users to monitor their health progress conveniently. The integration with Android applications, smart scales offer users a seamless experience by delivering real-time data, tracking long-term health trends, and offering personalized insights tailored to each user's fitness journey[1].

The manufacturing and production of a smart scale involve multiple stages, including hardware design, sensor integration, firmware development, mobile app development, and cloud connectivity. The hardware typically consists of high-precision sensors, a microcontroller (such as ESP32 or Bluetooth-enabled chips), and a durable platform. The accompanying Android app collects and visualizes data, supports multiple user profiles, and may integrate with fitness platforms like Google Fit.

This project bridges IoT (Internet of Things) and mobile technology, offering a modern solution for health-conscious consumers. By combining advanced manufacturing techniques with smart software development, the smart scale with an Android app represents a growing trend in personalized health monitoring...

In this project the first chapter sets the foundation for understanding the relevance of IoT in developing smart systems like the smart scale. The concept of the Internet of Things (IoT) is introduced, highlighting its impact on modern life and its role in connecting physical devices to the internet.it explores how IoT enables real-time data collection and intelligent decision-making in various fields such as healthcare, smart homes, and industrial automation.

The second chapter discusses the design of the smart scale system, detailing the selection of hardware and software components. It loads cell sensors for weight measurement, and communication modules such as Wi-Fi. The design also outlines how data is processed and sent to a cloud service like Firebase, and how it is later accessed through an Android application for user-friendly interaction.

In the third one , the practical steps of building and programming the smart scale are described. It covers assembling the components, writing the Arduino code, and integrating the system with Firebase and the mobile application. The chapter also highlights testing, troubleshooting.

Chapter 1 ：Internet of things

1.1 Introduction :

The Internet of Things (IoT) has transformed the way we interact with technology, embedding intelligence into everyday objects and enabling seamless connectivity between physical devices and digital systems. At the heart of this revolution lies the ability to collect, analyze, and act on real-time data—a capability that has profound implications for healthcare, smart homes, industrial automation, and beyond.

1.2 Définition :

More commonly known by its acronym IoT (Internet of Things), the Internet of Things (IoT) is the physical manifestation of the Internet. It involves every object, car, home, and other items connected to a physical Internet network through an electronic chip, a sensor, or network connectivity to allow them to communicate with each other and obtain and exchange data.

Thanks to the IoT, these materials can be controlled and tracked remotely through an underlying network infrastructure. They thus promise higher integration of the Internet into IT systems. The result is enhanced production, enhanced accuracy, and stunning economic benefits as a result of data achieved. Objects, with Big Data, provide essential information for businesses and individuals.

The Internet of Things (IoT) is a system of connected physical devices that collect and exchange data through the internet. Using sensors and network connectivity, these objects can be monitored and controlled remotely, improving efficiency, accuracy, and enabling smarter decision-making.

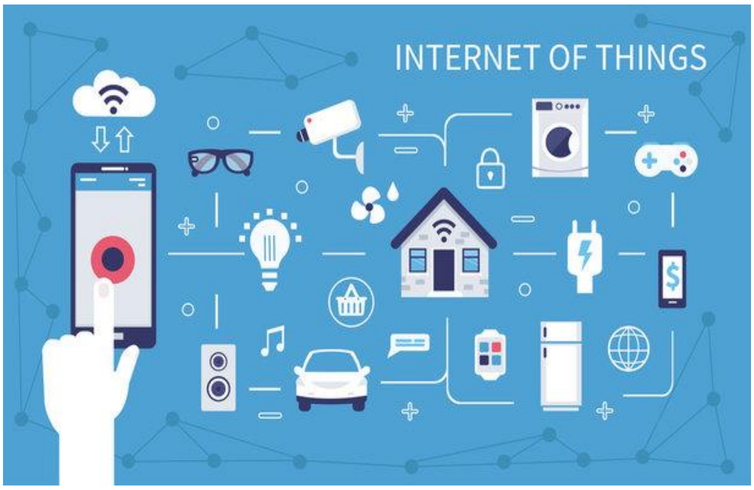

Figure.1.1:internet of things

1.3 History of Connected Objects:

The origins of the Internet of Things (IoT) can be linked to Rafi Haladjian, a French entrepreneur who played a key role in the early development of connected devices[1]. After founding France's first internet provider in 1994, he launched the company Violet in 2003 with the vision "Let all things be connected." Violet introduced the DAL lamp, an early connected object that reacted to data like weather or emails using colored LEDs[1]. In 2005, the company released Nabaztag, [1]. a Wi-Fi-enabled rabbit capable of reading emails and playing music, later rebranded as Karotz. Haladjian continued his innovations with the launch of Sen.se and the "Mother" system in 2014, which connected household objects through smart sensors, marking a major step in home automation and IoT[1].

1.4 Architecture :

The Internet of Things (IoT) is not a technology. Rather, it is a concept that brings different techniques into play simultaneously. Therefore, one must consider multiple systems simultaneously when discussing this concept.The following is a list of the various systems that are employed with the IoT **:**

- Identification: Authentication of every object and the aggregation of the information that it has collected.
- Network: Data transmission both online and offline.
- Sensor: Collection of data to enhance the functionality of the device.
- Interconnection: Interconnection of different systems.
- Integration: Internal sharing of data via system integration.

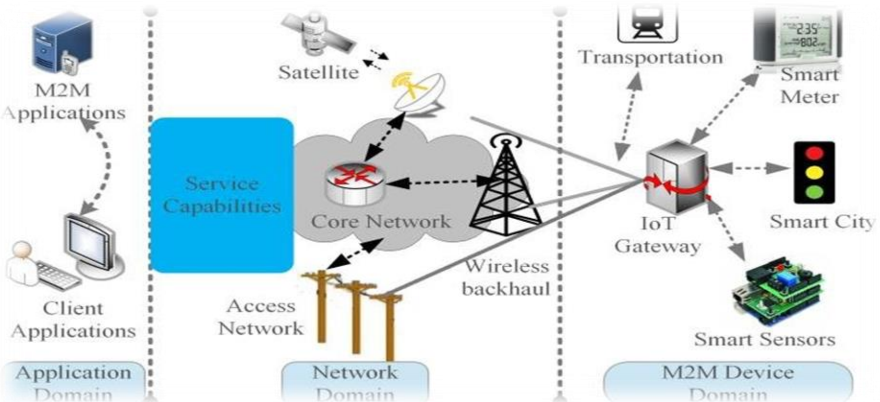

Figure.1.2: high-level architecture

1.5 Needs of IoT Systems :

Needs of lot Systems refer to the essential requirements that must be met for an Internet of Things (IoT) system to function effectively. IoT systems are characterized by four main needs:

1.5.1 Connectivity :

is the ability of IoT devices to transmit and receive data with other devices, networks, or cloud services using either wired or wireless communication methods. Possible forms of connectivity include:

- The object shares information with neighboring objects (local network).
- The object shares information over the Internet (global network).
- The object requires fixed or mobile communication (e.g., wearable devices).
- Or a combination of these features!

1.5.2 Analysis and Decision-Making :

The information produced by the objects is utilized worldwide (utilizing statistics and variability) on a grand scale.

1.5.3 Local Decision-Making :

- The decision-making is done locally (at the individual level) using the information generated by the objects.
- Or both.

1.5.4 The Temporal Need :

• The objects' generated information is of high temporal criticality (real-time).

• The information is not tightly constrained in processing delay.

1.5.5 The Need for Action :

- The decided actions are towards well-defined objects.
- The decided actions are executed on the objects statistically or randomly, or both.

1.6 Application Domains :

The Internet of Things (IoT) has a wide range of application domains, impacting nearly every sector by enabling smarter, more efficient systems.. the most prominent domains are :

1.6.1 Logistics:

- Application of RFID chips.
- Enables goods to be "smart" and trackable.
- Entire warehouses fully automated (e.g., Amazon).

1.6.2 The Pharmaceutical Industry :

- Biodegradable chips to prevent counterfeiting.
- Automatic prescription filling.

1.6.3 Healthcare :

- Enhanced self-awareness (e.g., sports, networked scales).
- Alert screening (e.g., blood pressure, pulse, etc.).

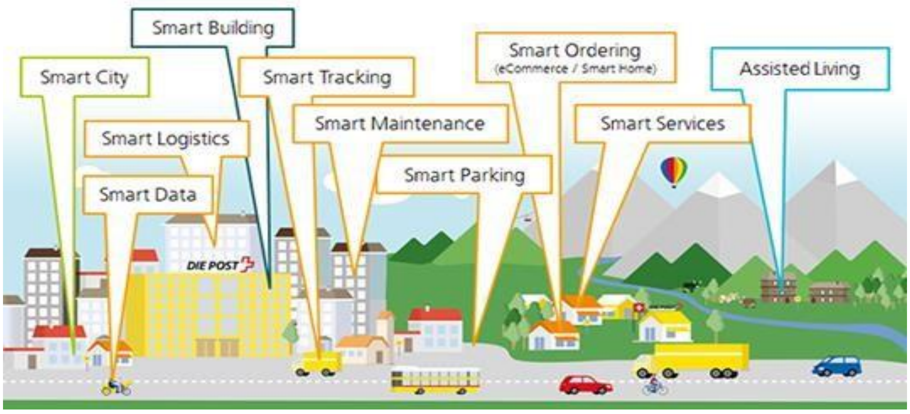

Figure.1.3: Scope of IoT applications[1] .

1.7 Dimensions of the Internet of Things :

The dissemination of the Internet of Things (IoT) may have adverse economic and social consequences, prompting the implementation of preventive and anticipatory measures to reverse such effects. [1] .

1.7.1 Economic Dimensions :

The following cautionary practices are indispensable and prudent: Conducting initial checks to ascertain the viability, profitability, and reliability of every potential application. Ensuring coherence and robustness of a distributed value chain between different actors. Building the ability for instant processing of mass streams of information through high-performance communication networks. Inventing and imagining new innovative business models in line with the evolving technological environment. [1] .

1.7.2 Dimensions at the societal level :

The preservation of user privacy and behavioral integrity is an inherent necessity: Restricting monitoring activities to objects only, hence blocking profiling and identification of people. Setting definite criteria on the nature of data to be retained and appropriate data retention periods. Bringing the uses of technology into line with users' cultural environments and usage patterns, making it more usable and accessible. Clearly notifying the public about the new functionalities and services available. [1] .

1.7.3 Dimensions of Regulation :

Personal data protection can be achieved by merely assigning responsible third parties with a mandate to deliver security, integrity, and controlled disclosure of data assets. Besides, to facilitate seamless interoperability between IoT systems, it is important to standardize communication protocols and frequencies[1] .

1.8 The benefits of Internet of Things :

There are currently over 100 million connected IoT devices being utilised across various industries. By 2030, the number of connected IoT devices is forecast to exceed 8 billion. This exponential adoption of IoT is a testament that organisations worldwide are recognising and leveraging the numerous advantages of IoT.

A. Reduced costs :

IoT technologies are reducing operational costs across various sectors. Through the automation of processes and the use of real-time monitoring, organisations can cut down on manual labour nd minimise errors. This leads to more efficient resource utilisation and lower expenses. IoT also enables predictive maintenance, helping prevent costly downtimes and the costs of unforeseen equipment failures.

B. Improved safety :

From manufacturing warehouses to hospitals to construction sites, IoT applications can improve workplace safety across various industries. Organisations can utilise the sensors in IoT devices to monitor workplace environments, helping to identify any potential hazards before they lead to accidents. This allows a proactive approach to safety, reducing any workplace injuries and fatalities

C. Increased productivity :

IoT drives productivity by streamlining processes and enabling more efficient task management. Connected devices provide real-time data that can be used to optimise workflows and reduce downtime of machinery. These advancements the benefits of Internet of Thing help organisations to operate more effectively, reduce costs, and focus on strategic initiatives that drive growth and success.

D. Improved customer expérience :

IoT helps organisations improve their customer experience by enabling more personalised and responsive services. Connected devices can gather detailed customer data, allowing businesses to tailor their offerings and anticipate customer needs ,This personalisation enhances customer satisfaction and fosters loyalty.

E. Data collection :

IoT devices can collect and share vast amounts of data through embedded sensors, software, and other technologies. This continuous data exchange provides organisations with a wealth of information for analysis and strategic decision-making. This data-driven approach enables organisations to understand market trends, customer behaviour, and operational inefficiencies more accurately.

F. Predictive maintenance :

Predictive maintenance is a standout benefit of IoT. IoT devices constantly monitor equipment performance, allowing them to accurately forecast maintenance needs. This allows for timely intervention before the issue escalates, preventing any unexpected breakdowns that cause interruptions to operations. Predictive maintenance also enhances the safety of the workplace by preventing malfunctions that could result in accidents or injuries.

1.9 Potential désavantages of IoT :

The internet of things isn’t all rainbows and puppy dogs, of course. There are plenty of hurdles and potential problem areas to resolve as everyone works with these technologies. Additionally, tech experts do have concerns about what the IoT can enable and how that might impact society. Here are some of the potential drawbacks. [1] .

A. Increased tracking and privacy issues :

All that data pouring in from IoT devices goes somewhere. “There is a tremendous treasure trove of data about us that is outside of our control,” Mustac points out, adding that this data can be misused.

Navigating secure and ethical usage of all that data is a huge deal, and it’s now a subject of regulation at the federal level. The debate around how companies should be allowed to access and utilize user data is ongoing.

B. weaknesses in network security:

In addition to concerns about how companies legally use the data collected from IoT devices, there are serious worries about illegal access. Wills points out that a major issue with IoT is the lack of proper security, as many manufacturers treat it as an afterthought. Vulnerabilities like hardcoded passwords and outdated software make it easy for hackers to infiltrate networks. As the number of connected devices grows, so does the risk. Cybersecurity consultant Therese Schachner emphasizes that strong security protocols, including secure user authentication and data encryption, can help reduce these threats. With devices that can see and hear in private spaces, both consumers and companies want assurance that their data isn’t being shared with just anyone—making cybersecurity roles more critical than ever.

C. required bandwidth :

The more internet-connected things you have in an environment, the more bandwidth they are going to demand. “As a result, devices on the shared network may experience slower internet speeds,” Schachner says. Since many people are already struggling with the amount of bandwidth they have access to, this can be a serious drawback to IoT implementation.

“The widespread adoption of IoT devices requires networks to be able to support a substantial number of additional connections.” [1]

D. Increased monitoring time :

The bandwidth issue also relates to professionals and the time they may have to spend keeping an eye on IoT devices. While it’s unlikely to be a time-drain for individuals with a few home devices, cyber security professionals could find themselves totally bogged down in logging and monitoring for corporate IoT devices, according to Wills.

Figure.1.4: IOT Security

1.10 Conclusion :

In this chapter we have established that the Internet of Distributed Objects (IDO) fundamentally depends on robust telecommunication capabilities, encompassing both local and remote data transmission. Throughout this discussion, we explored its architectural framework, identified key application domains, and examined its technical requirements. Furthermore, we addressed several related dimensions of the broader Internet of Things (IoT) landscape, including its financial implications and social impact.

Chapter 2 :system design

2.1 Introduction :

This chapter presents the system design of the smart scale project, detailing the key components and their integration to achieve a functional and connected device. The smart scale system is composed of hardware elements,and a custom-built Android application that offers real-time monitoring and an intuitive user interface.The chapter outlines the design and interaction between the hardware, sensor integration, cloud database, and mobile application that collectively form the complete smart scale system.

2.2 Operating principle :

The smart weighing system is fully integrated and begins operation :

- When the user steps onto the smart scale. The scale is equipped with a load cell sensor that converts the applied force into a weak electrical signal.
- This signal is sent to the HX711 module, which amplifies it and converts it into a digital signal.
- The digital data is then transmitted to an ESP32 microcontroller, which connects to Wi-Fi and sends the data directly to the Firebase Real time Database using HTTP or REST APIs.
- Firebase stores the data in real time and synchronizes it with an Android app developed using MIT App Inventor. The app retrieves and displays the data in a user-friendly graphical interface.
- Additional features include measurement history, a chart tracking weight changes over time, and automatic notifications when the user's weight exceeds predefined thresholds.

This system offers seamless integration of electronic and software components, delivering a smart and convenient weight monitoring experience

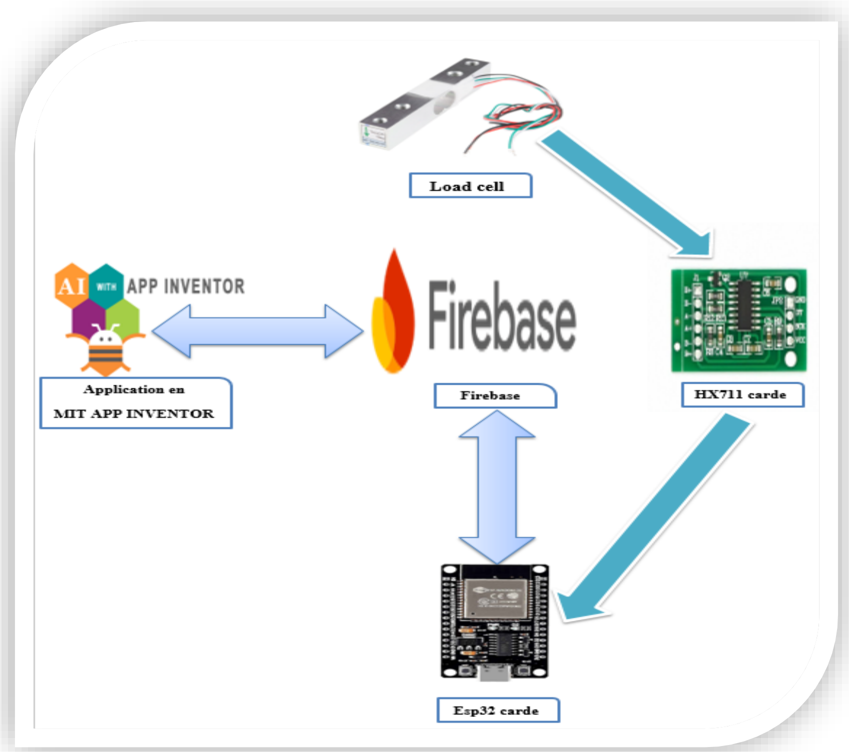

Figure.2.1: different blocks of the application

2.3 Architecture :

In this project, the smart scale is built on an integrated technical architecture that starts with sensors and ends with a mobile application.

- ✓ A load cell is used to measure weight, and its analog signal is converted into digital data using the HX711 module.
- ✓ The ESP32 microcontroller reads this data and connects to the internet via Wi-Fi, using the NTP protocol to synchronize the time accurately. The data is then sent in JSON format over HTTP to the Firebase Real-time Database, where it is stored and organized.
- ✓ Finally, a mobile app developed using MIT App Inventor retrieves and displays the data to the user, enabling real-time weight tracking in a simple and user-friendly manner.

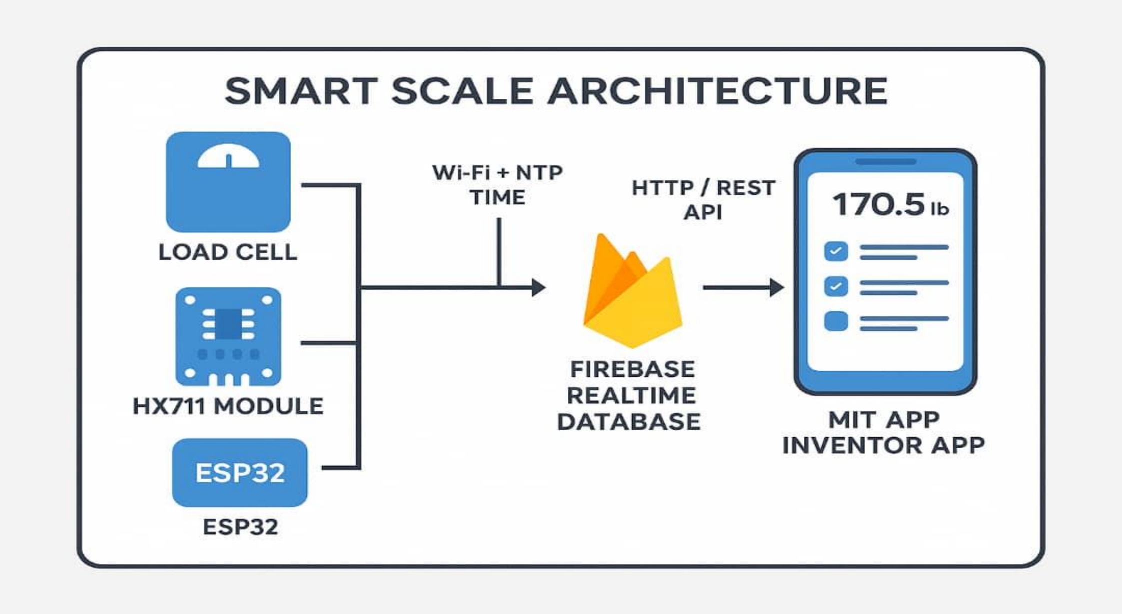

Figure.2.2: Smart Scale System Architecture

2.4 Components:

2.4.1 Load cells :

Load cells are sensors used to measure weight or force by converting mechanical pressure into electrical signals that can be interpreted by a controller or measurement system.

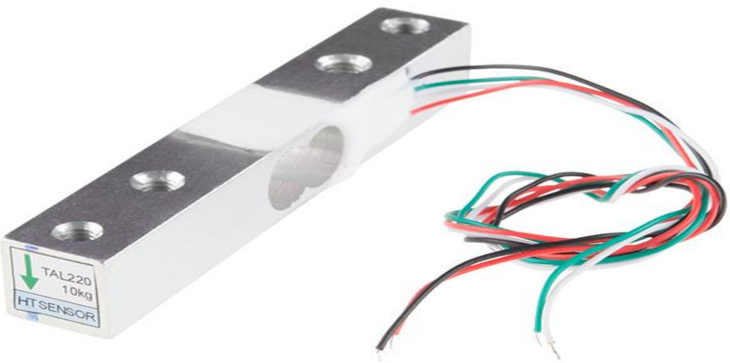

Figure.2.3 : Numerous load cells

2.4.1.1 Strain Gauge Load Cells :

Strain gauge load cells are one of the most widely used types of load cells. They operate based on a mechanical element that deforms under applied force [3].

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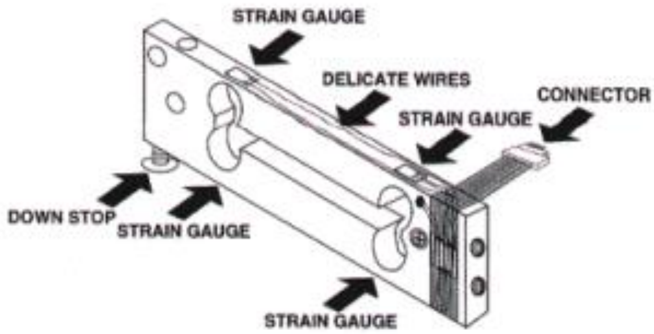

Figure.2.4: Strain gauge load cell diagram

In bar strain gauge load cells, the sensing element is configured in a "Z" formation where applied torque creates bending stress in the bar. Four strain gauges are precisely mounted to measure this deformation - two positioned to detect compression and two to measure tension. When connected in a Wheatstone bridge configuration, this arrangement enables precise measurement of the minute resistance changes in the strain gauges .

This type of load cell is known for its accuracy, reliability, and suitability for a wide range of industrial and commercial weighing applications

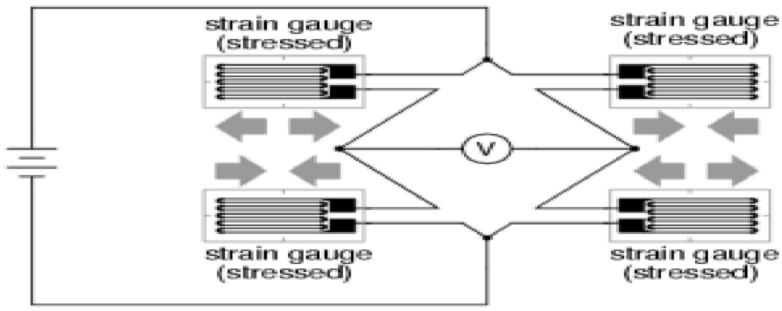

Figure.2.5: Bar load cell Wheatstone bridge example From All About

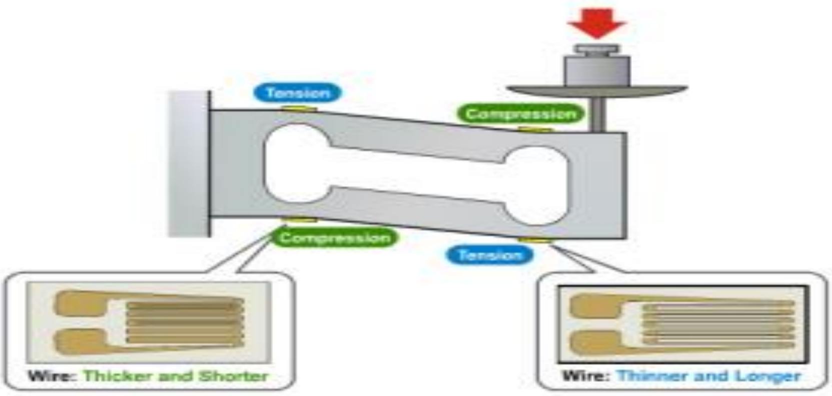

Figure.2.6: Schematic diagram of strain gauges on load cells

2.4.1.2 Strain Gauge Basics :

A strain gauge is a device that measures electrical resistance changes in response to, and proportional of, strain (or pressure or force or whatever you so desire to call it) applied to the device. The most common strain gauge is made up of very fine wire, or foil, set up in a grid pattern in such a way that there is a linear change in electrical

resistance when strain is applied in one specific direction, most commonly found with a base resistance of 120Ω, 350Ω, and 1,000Ω. Each strain gauge has a different sensitivity to strain, which is expressed quantitatively as the gauge factor (GF). The gauge factor is defined as the ratio of fractional change in electrical resistance to the fractional change in length (strain).

Table 2.1: load cell properties

Specifications:		
capacity	kg	3,5,10,20,25,30,50(aluminum); 80,100,120,200(alloy steel)
safe overload	%FS	120
ultimate overload	%FS	150
rated output	mV/V	1.0 ± 0.15
excitation voltage	Vdc	5 - 10
combined error	%FS	± 0.05
zero unbalance	%FS	± 0.1
non-linearity	%FS	± 0.05
hysteresis	%FS	± 0.05
repeatability	%FS	± 0.03
creep	%FS/3min	± 0.05
input resistance	Ω	1000 ± 15
output resistance	Ω	1000 ± 10
insulation resistance	M Ω	≥ 2000
operating temperature range	℃	-10 - +55
compensated temperature range	℃	-10 - +40
temperature coefficient of SPAN	%FS/10℃	± 0.05
temperature coefficient of ZERO	%FS/10℃	± 0.05
Electrical connection	cable	4 color wire (standard)or 4 shielded PVC cable, Ø0.8 × 220 mm

2.4.1.3 Features of load cells :

- 50kg and 200kg, Disc/Button-Type (TAS606)
- 200kg, S-Type (TAS501)
- 10kg, Straight Bar (TAL220)
- 5kg, Straight Bar (TAL220B)
- Mini Load Cell - 500g, Straight Bar (TAL221)
- Mini Load Cell - 100g, Straight Bar (TAL221)

2.4.2 HX711 :

The HX711 is an active signal transformer (ADC), specially designed to read small voltage signals resulting from cell loads and convert them into signaling and digital data [4].

Load cells use a four-wire to connect to the HX711. These are commonly colored RED, BLACK, WHITE, GREEN and YELOW. Each color corresponds to the conventional color coding of load cells.

- Red (Excitation+ or VCC)
- Black (Excitation- or GND)
- White (Amplifier+, Signal+ or Output+)
- Green (A-, S- or O-)
- Yellow (Shield)

The YLW pin acts as an optional input that is not hooked up to the strain gauge but is utilized to ground and shield against outside EMI (electromagnetic interference). Please keep in mind that some load cells might have slight variations in color coding[4].

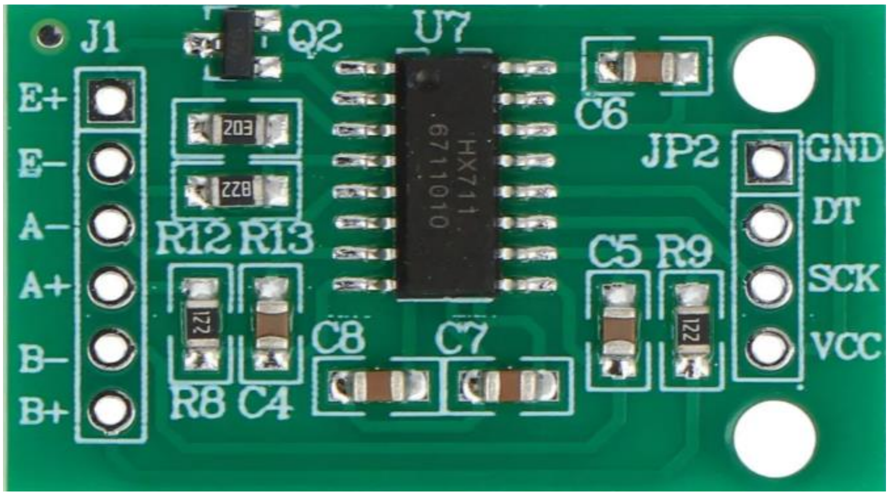

Figure.2.7: The HX711 board

2.4.3 ESP32 :

The ESP32 is an integrated 2.4 GHz Wi-Fi and Bluetooth system-on-chip (SoC) fabricated using TSMC's 40 nm low-power process technology**.** Engineered for optimal power efficiency and radio frequency (RF) performance**,** the device demonstrates high robustness, operational versatility, and reliable functionality across diverse application domains and power-constrained environments. The important features Highlighted[4].

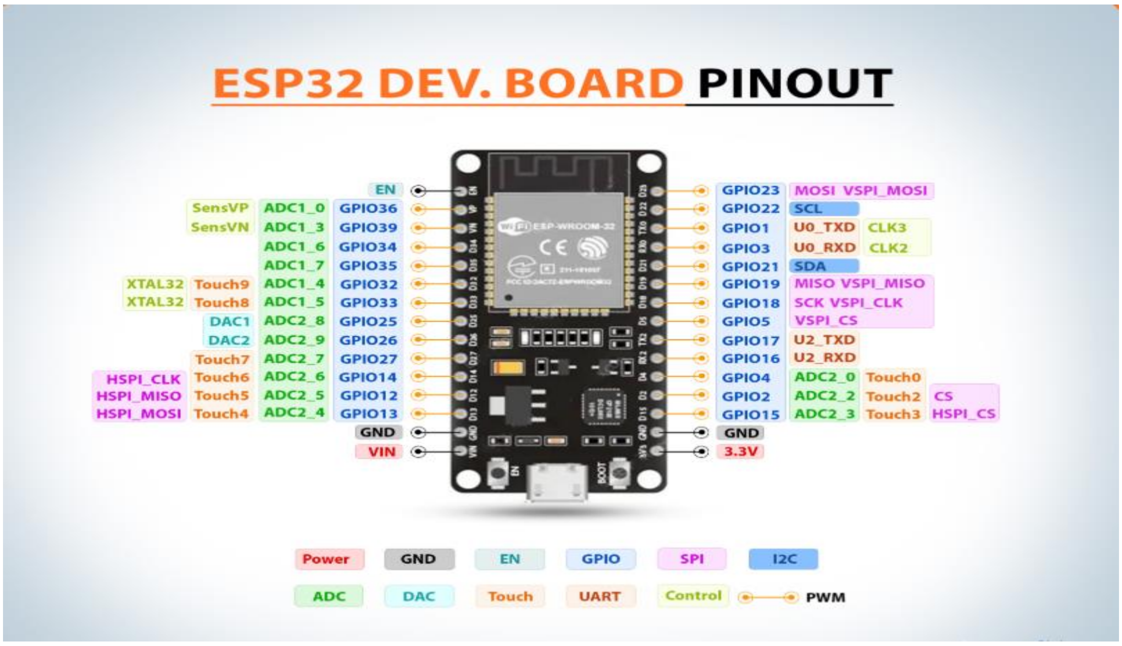

Figure.2.8: ESP32 Digramme.

A. Robust Design :

ESP32 is capable of functioning reliably in industrial environments, with an operating temperature ranging from –40°C to +125°C. Powered by advanced calibration circuitries, ESP32 can dynamically remove external circuit imperfections and adapt to changes in external conditions. [4].

B. High Level of Integration :

ESP32 is highly-integrated with in-built antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules. ESP32 adds priceless functionality and versatility to your applications with minimal Printed Circuit Board (PCB) requirements. [4].

C. Hybrid Wi-Fi & Bluetooth Chip :

ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor. ESP32 can interface with other systems to provide Wi-Fi and Bluetooth functionality through its SPI / SDIO or I2C / UART interfaces. [4].

D. Ultra-Low Power Consumption :

Engineered for mobile devices, wearable electronics and IoT applications, ESP32 achieves ultra-low power consumption with a combination of several types of proprietary software. ESP32 also includes state-of-the-art features, such as fine-grained clock gating, various power modes and dynamic power scaling. [4].

2.5 Software environment:

2.5.1 Firebase :

Firebase is a web application platform. It helps developers to create quality apps. It stores data in JavaScript Object Notation (JSON) Format which requests do not use to insert, update, delete or add data into it. Backend of this system is used as a database to store data [2]. Services offered are :

- ✓ Firebase Analytics
- ✓ Firebase Cloud Messaging (FCM)
- ✓ Firebase Auth :
- ✓ Firebase Real-time Database Firebase
- ✓ Firebase Storage
- ✓ Firebase Test Lab
- ✓ Firebase Crash
- ✓ Firebase Notifications

2.5.2 Firebase Real-time Database:

Firebase Real-time Database is cloud-hosted. It stores data in JSON and synchronizes real-time to all the connected clients. When you create cross-platform applications with iOS, Android, and JavaScript SDKs, all your clients share the same Real-time Database instance and automatically receive updated with the latest data[5].

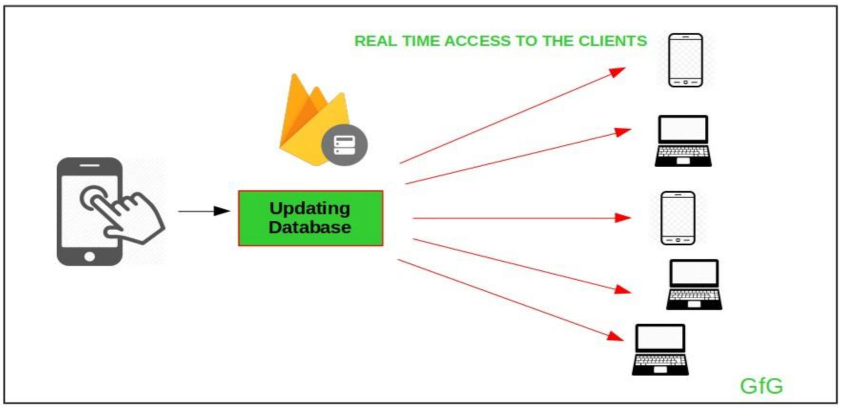

Figure.2.9: Firebase Real-time Database.

2.5.3 MIT App Inventor:

MIT App Inventor is an environment for software development that was created by MIT to enable the development of interactive Android applications quickly without resorting to sophisticated programming practices. The user interface of the MIT App Inventor facilitates the construction of different application types using easy-to-use and simple visual elements. The relevance of MIT App Inventor in the manufacturing and production of smart scales is that it is simple to use and accommodates smart device control technologies. Through it, one is able to design apps for handling smart scales, such as displaying weight, data storage, and synchronization of data between other devices. MIT App Inventor facilitates creating applications surrounding smart scales more conveniently so that the user is able to connect the scale to the application more conveniently and successfully [6].

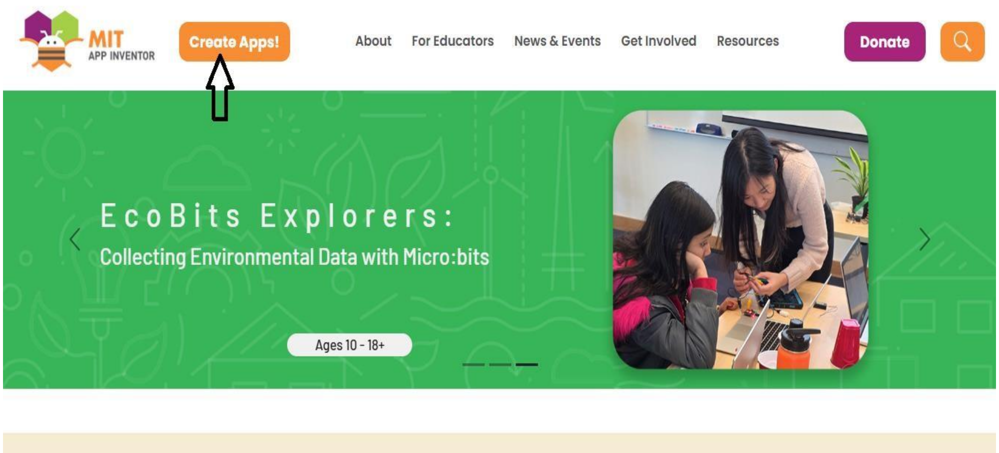

Figure.2.10: Interface MIT APP INVENTOR. [6].

2.5.4 Arduino Platform:

For the project of creating and manufacturing a smart scale that is integrated with an Android app, the Arduino platform was chosen as the primary microcontroller due to its simplicity in working with and versatility. The Arduino IDE, built in Java and founded on the Processing language, provides an integrated programming interface that assists users with entering code, compiling it, and sending it to the Arduino board directly by using various communication technologies such as USB, Bluetooth, or serial (RS-232), depending on the module type. The site also allows for the use of a command-line interface as opposed to a graphical configuration, and greater flexibility for automated development or customization[7].

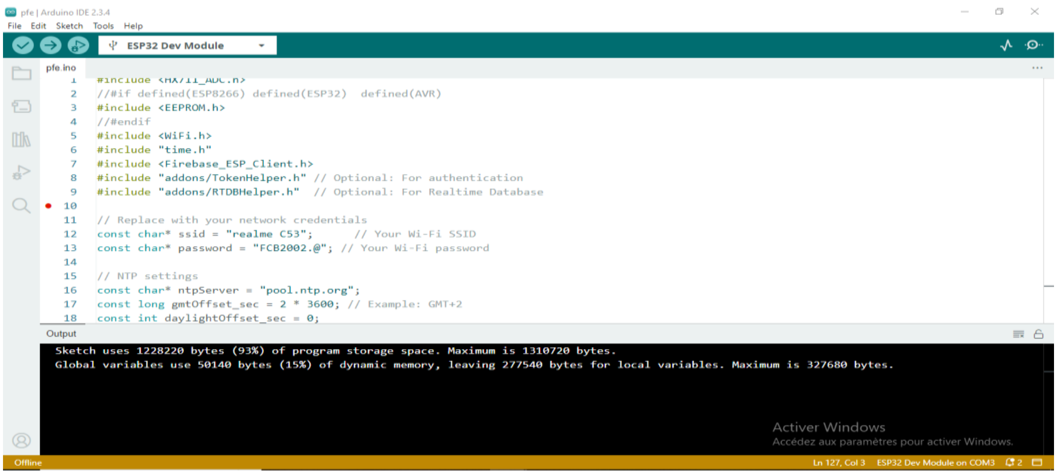

Figure.2.11:Aduino IDE [7].

2.6 General flow chart of system :

The flowchart shows how the ESP32-powered smart weight measurement system works. The weight is first read from the load cell sensor to start the procedure. The sensor's very weak analog signal is amplified by the HX711 module, which also transforms it into a processable digital value. This value is then read and processed by the ESP32. The system determines whether a Wi-Fi connection is accessible before transferring any data. The user can examine the weight data using the mobile application after it is transmitted to the Firebase cloud database, if it is connected. In the event that there is no connection, the system waits for a link to be established before sending the data. This sequence illustrates the intelligent and user-friendly collection, processing, transmission, and display of data.

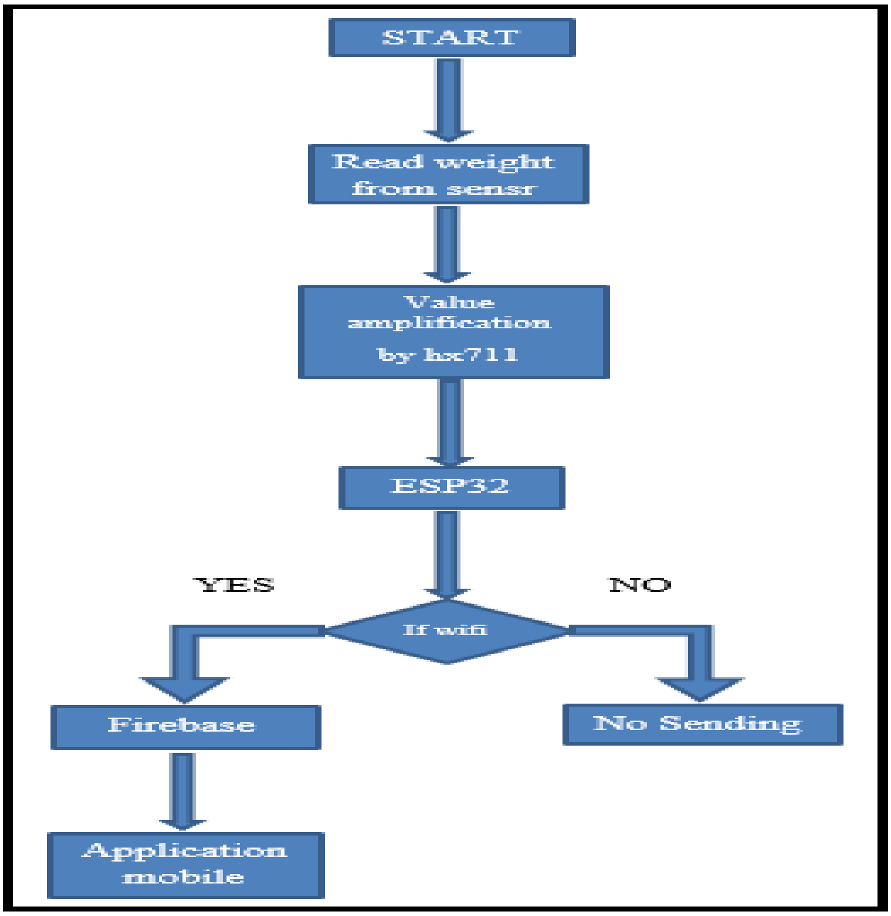

Figure.2.12:Flowchart of the smart scale system

2.7 Conclusion :

This chapter summarized the design of the smart scale system, covering both hardware and software components. Key elements such as the ESP32, load cell, and HX711 were selected for their efficiency and accuracy. The system architecture was carefully planned to enable real-time data collection and transmission to the mobile app via Firebase.

Chapter 3 :project realization

3.1 Introduction :

The practical development of the smart scale project is the topic of this chapter, focusing on its production and manufacturing process. The smart scale incorporates sensors for precise weight measurement and a specially developed Android application for real-time monitoring and user interface. The system saves and synchronizes user data in real-time across devices through Firebase Real-time Database, enabling easy access to weight history anywhere. . This chapter identifies the hardware development, sensor integration, Firebase link, and app programming that combined to bring smart scale animation into being

3.2 Functionment :

The smart weighing system is fully integrated. It begins by measuring the user's weight when they step onto the smart scale, which is equipped with a load cell sensor that converts the resulting force into a weak electrical signal. The signal is transmitted to the HX711 module, which amplifies it and converts it into a digital image that is fed to an ESP32 microcontroller. The controller connects to a Wi-Fi connection and sends the data directly to the Firebase.

Real time Database cloud using HTTP or REST APIs. Firebase stores the data in real time and syncs it to an Android app developed in collaboration with MIT App Inventor, which retrieves the data in real time and displays it in an easy-to-use graphical format. The app also offers other features such as a measurement history, a chart showing weight change over time, and automatic notifications when weight exceeds certain levels. This system provides an efficient integration of electronics and software components to provide a smart and convenient weight monitoring experience

3.3 Hardware development:

3.3.1 Connection between the Load Cell and the HX711 Module

Wires used :

- E+ (Excitation +) ← for positive power
- E− (Excitation −) ← for ground
- A+ and A− ← for signal output from the sensor

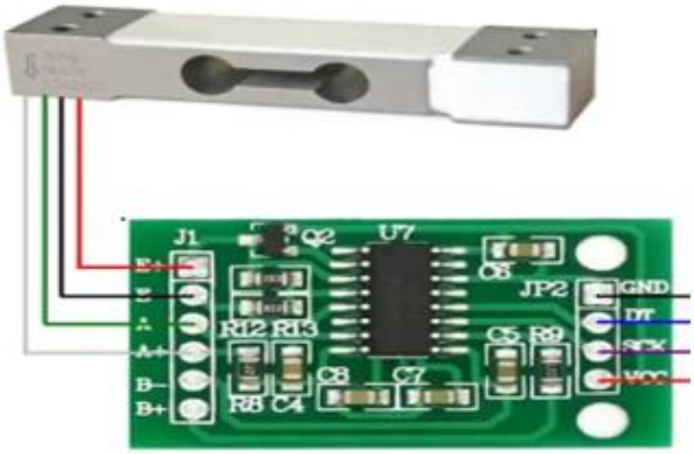

Figure.3.1: Electrical wiring between the load cells and the Hx711 module

3.3.2 Connection between HX711 and ESP32 :

The figure 3.2 illustrates the connection between HX711 and ESP32 via four poles :

Function :

- The HX711 converts the weak analog signal from the load cell into a digital signal that can be read by the ESP32.

Connections:

- DT (Data) → to GPIO 17 on the ESP32
- SCK (Clock) → to GPIO 18 on the ESP32
- VCC → to 3.3V or 5V, depending on the HX711 model
- GND → to GND on the ESP32

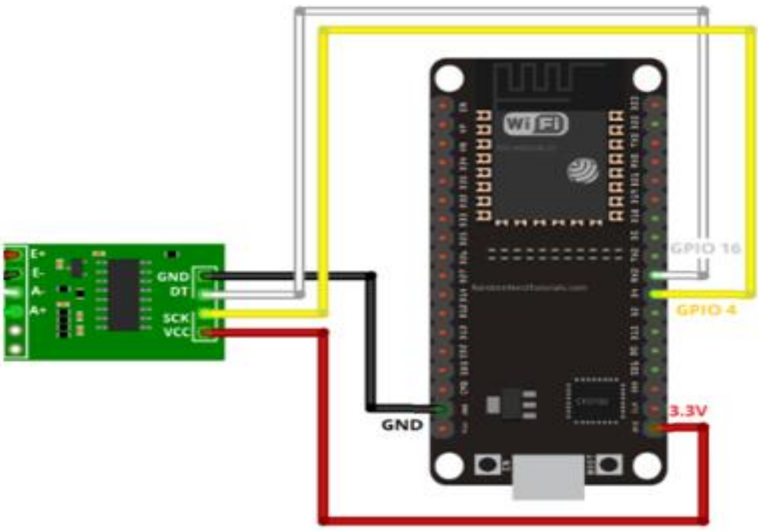

Figure.3.2: Electrical wiring between the HX711 module and the ESP32

3.3.3 Check Signal Stability:

Signal stability is critical for reliable communication in IoT-based systems. To ensure reliable performance in IoT or remote systems, follow these steps to verify signal stability:

Make sure the GND of the HX711 is connected to the GND of the ESP32 to create a common voltage reference

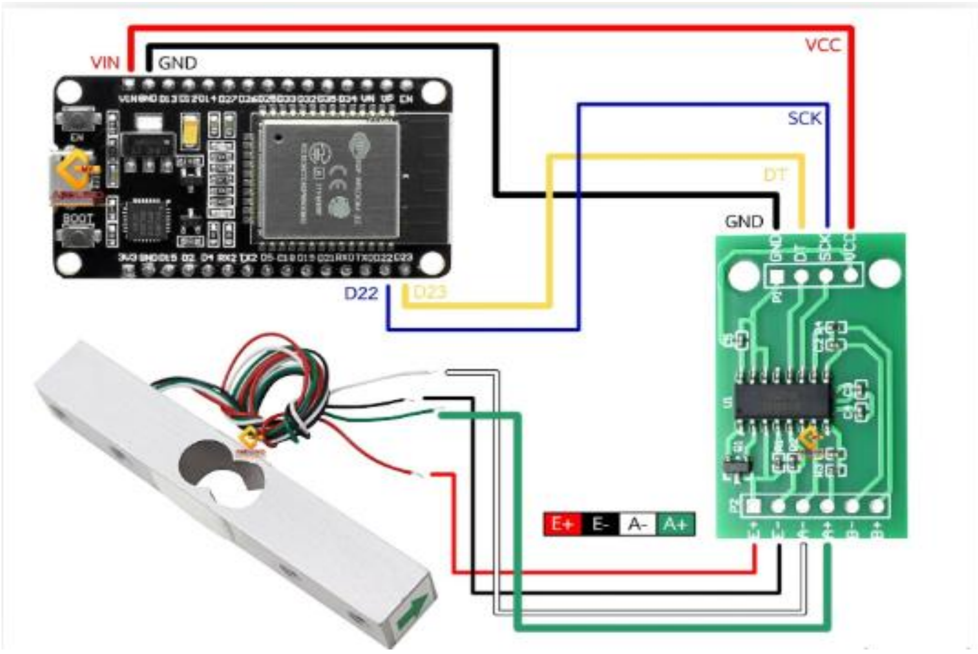

Figure.3.3: General electrical diagram of the smart scale

3.4 Software Development :

The software component is a critical element in an Internet-based smart scale, enabling centralized management, automation, and remote monitoring.

3.4.1 ESP32 Smart Scale Project Code:

An Arduino C++ code is used to connect a load cell via an HX711 amplifier to an ESP32 microcontroller and then send the weight reading to a Firebase Realtime database with date logging via NTP (Network Time Protocol).

3.4.1.1 Libraries used:

- **EEPROM.h:** A built-in library in the Arduino IDE that provides access to the EEPROM of the microcontroller.It retains data even after a reboot**.**
- **WiFi.h:** Used in connecting the ESP32 module to the internet.
- **Time.h:** To get the current time from the Internet (NTP).

- **Firebase_ESP_Client.h:** The library that manages communication with Firebase.
- **TokenHelper.h and RTDBHelper.h:** Optional files that assist in authentication and database access

3.4.1.2 Wi-Fi & Firebase Configuration:

- We replaced "wifi name" and "password" with the name and password of our own Wi-Fi network.
- We also entered the Firebase project link (load cell) and the legacy token to access the database.
- Time is synchronized using an NTP server (pool.ntp.org) for accurate date logging.

➢ **Load Cell & EEPROM Setup:**

- The HX711 load cell amplifier is connected to ESP32 on pins DOUT (GPIO18) and SCK (GPIO 17)
- LoadCell is the object responsible for reading the weight.
- calVal_eepromAdress: The EEPROM address that stores the calibration value.
- fbdo: Firebase Data object to handle data transactions
- auth and config: Firebase authentication and connection setting.

3.4.1.3 setup() function:

It contains the following steps:

➢ **Initiate serial communication and verify HX711:**

- Serial communication begins.
- Initialize the HX711 and load the calibration factor from the EEPROM.
- Perform the "tare" operation (zero the scale).
- Set the calibration factor to convert the values to actual weight.

➢ **Connect to Wi-Fi & Configure Firebase:**

- connects to Wi-Fi and prints device IP.
- Initializes Firebase connection using config and auth.
- Synchronizes local time using configTime() with the NTP serve

3.4.1.4 The loop() function:

runs continuously and performs:

- Data Update : Continuously checks for new data from HX711.
- Send to Firebase : If new weight is available, it's sent to Firebase along with a date string.
- Tare via Serial : Typing 't' into the Serial Monitor triggers a tare operatio

3.4.1.5 sendToFb() function:

- Sends the weight to a path within the firebase database.
- Date is a string representing the current date (such as "2025-05-08").

It prints the submission results :

- **If sent successfully:**

Serial.println("String sent successfully!");

Serial.println("Path: " + fbdo.dataPath());

Serial.println("Value: " + fbdo.stringData());

- **If sent unsuccessfully:**

Serial.println("Failed to send string!");

Serial.println("Reason: " + fbdo.errorReason());

3.4.1.6 getCurrentDate() function:

- getLocalTime() is used to retrieve the local time from the Internet (NTP).
- It is formatted as YYYY-MM-DD.
- The date is returned as a string for use in a Firebase path

3.5 Firebase Database Working in a Smart Scale System:

Firebase Real-time Database is an ideal solution for smart device applications such as smart scales integrated with Android apps. It provides a secure and efficient platform for real-time data storage and synchronization. The application can directly and securely access the database, allowing seamless recording and monitoring of data such as weight, BMI, and historical records.

Firebase also supports local data caching, enabling the application to remain functional even during internet outages. Once connectivity is restored, the data is automatically synchronized with the server, with intelligent merging to prevent data loss or conflicts.

As a NoSQL database, Firebase offers great flexibility in structuring data to fit the specific needs of the system. Additionally, its robust security rules system allows fine-grained access control, especially when integrated with user authentication, ensuring strong protection of user privacy.

Thanks to its well-designed API, Firebase delivers high-speed and reliable performance, capable of supporting thousands of users simultaneously—making it an excellent choice for smart scale systems that demand real-time interaction and high stability.

3.5.1 data structure:

After programming the ESP32 to read the weight and send it to Firebase every 4 seconds along with the date, the data is stored in the Firebase Real-time Database, a cloud-based NoSQL database that supports instant and secure synchronization between devices with strong permission controls to protect user privacy

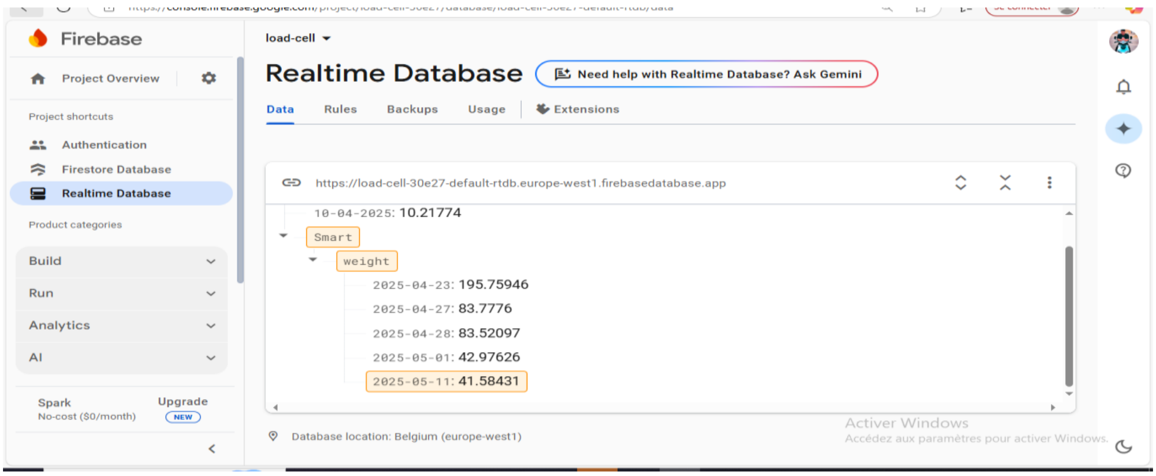

Figure.3.4 : Storing smart scale data in Firebase

3.6 Online User Interface :

A graphical interface that allows users to interact with the weight control , accessible via a web browser.

This interface is a dedicated platform for system administrators or managers. It provides advanced functionalities for configuring the system, optimizing usage Application. Key tasks performed by administrators include :

User Management: The interface allows administrators to manage users who have access to the Application . This may include creating user accounts, managing permissions and roles, and revoking access as needed.

System Configuration: Administrators can use the interface to set general parameters for weight . This may involve defining default watering schedules, setting sensor thresholds, and more.

Monitoring and Data Visualization: The interface may provide dashboards and charts for real-time monitoring of weight data. Administrators can view sensor information,, alerts, and other relevant data.

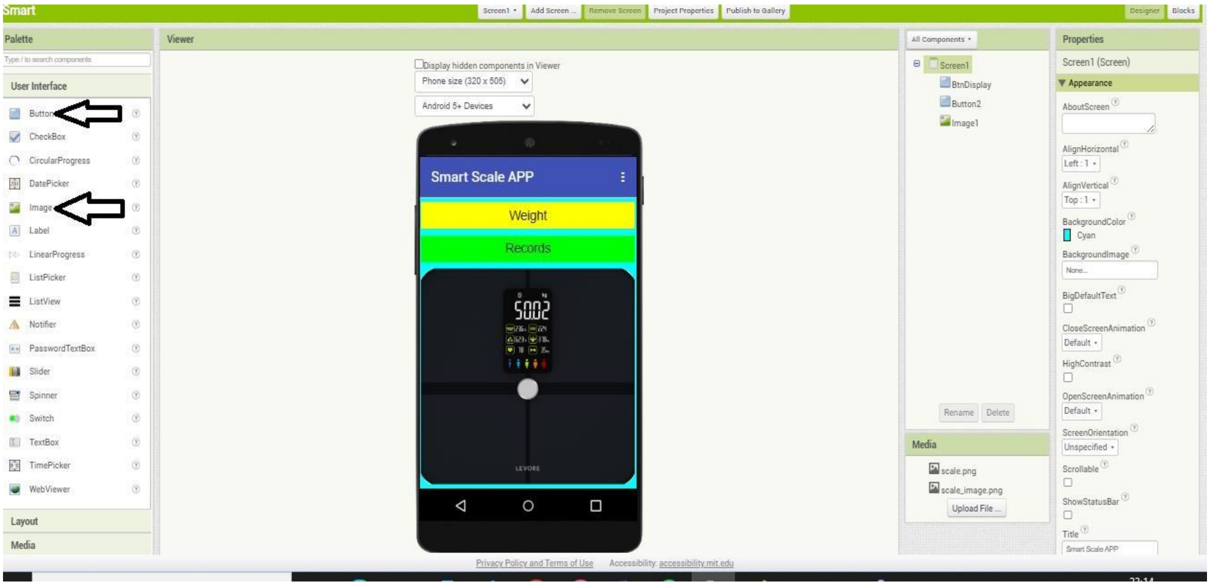

Figure.3.5 :Online User Interface

3.6.1 The Blocks Editor :

3.6.1.1 First interface :

This is where you will program the app’s behavior. Here, you will add the commands that define how the app works. As mentioned earlier, you can access it by clicking the Blocks button at the top right

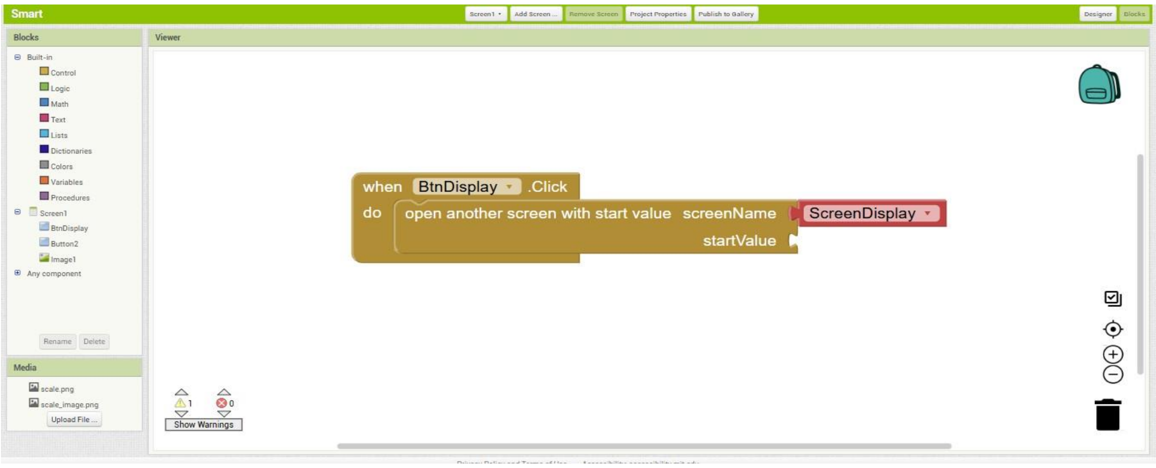

Figure.3.6: Blocks Home page for Application

click the button, this box opens the active screen.

3.6.1.2 Second interface :

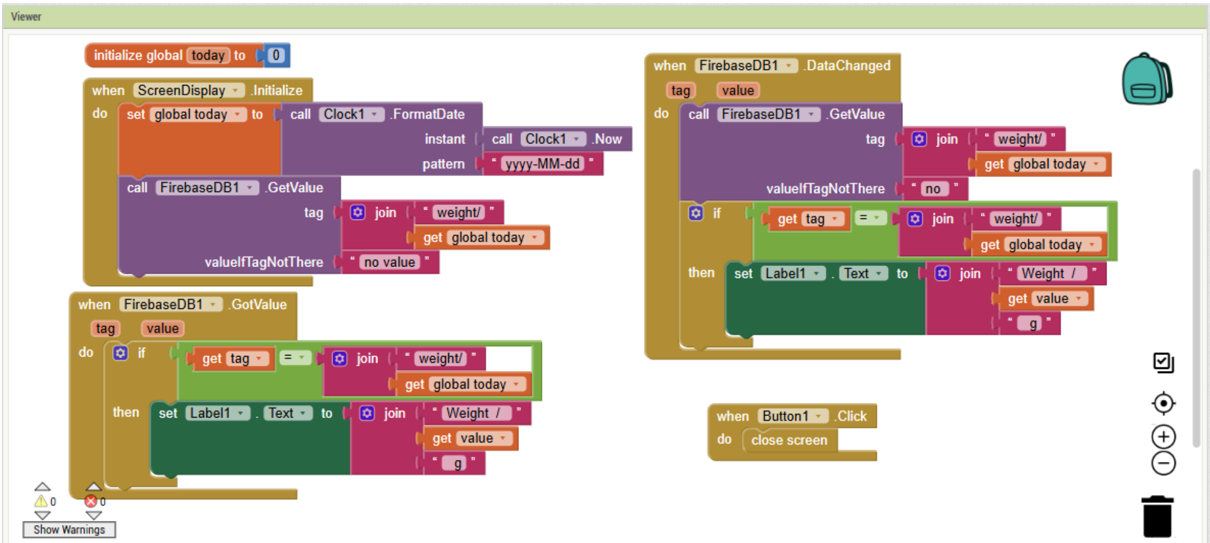

Figure.3.7: Blocks Second page for Application

- **Set today's global beginning value to 0 :**

The global variable named today is created by this block, and its initial value is set to 0.

In order to access the right route in Firebase, it will be utilized to save the current date in the format yyyy-MM-dd.

- **when the screen Display Initialize :**

When the Screen Display screen launches, this event is triggered.

Within this block:

- set Clock1.FormatDate(...) as the global date today.puts the current date in the today variable after formatting it as yyyy-MM-dd (for example, 2025-05-12).
- Get Value from FirebaseDB1.
- uses the path weight/today to request data from Firebase (e.g., weight/2025-05-12).
- It returns "no value" if there is no value.

➢ when Got Value in FirebaseDB1 :

When a value is received from Firebase, this block is activated.

Inside:

- IF condition: Verifies that the received tag equals the weight and the current day.
- The weight is then displayed in the format "Weight / XX g" if true, with XX being the value obtained from Firebase.

➢ when the data in FirebaseDB1 :

Description: Activated whenever any Firebase data updates.

Inside:

- retrieves the modified value from the weight/today path by making another call to Get Value.
- Verifies that the modified tag is on the correct path. If so, Label1 is updated.Add the updated weight value to the text.

➢ When the Button1.Click :

Description: When the button is pressed, this block shuts the active screen.

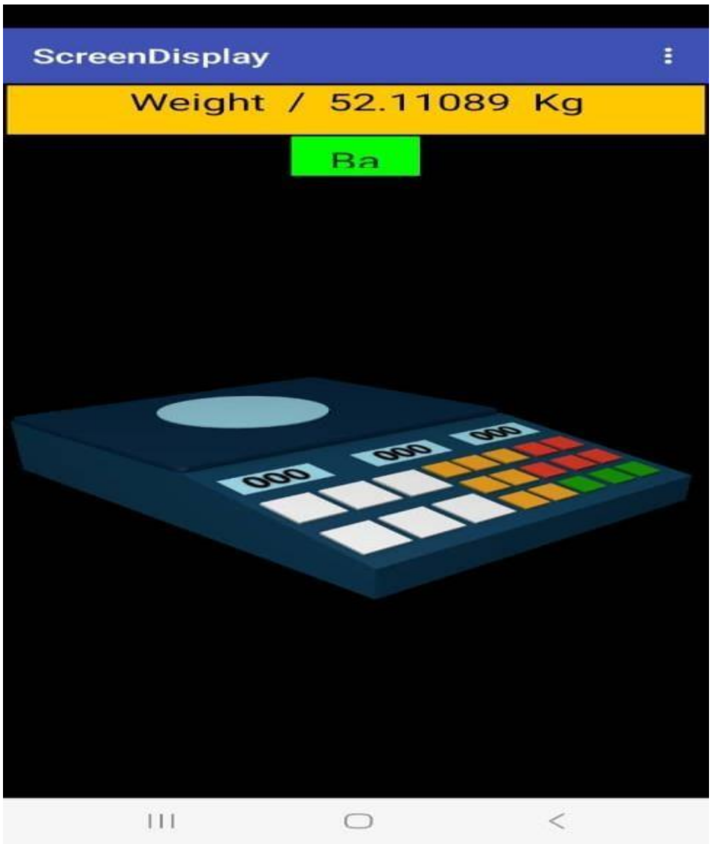

Figure.3.8: Display weight

3.7 Project Work :

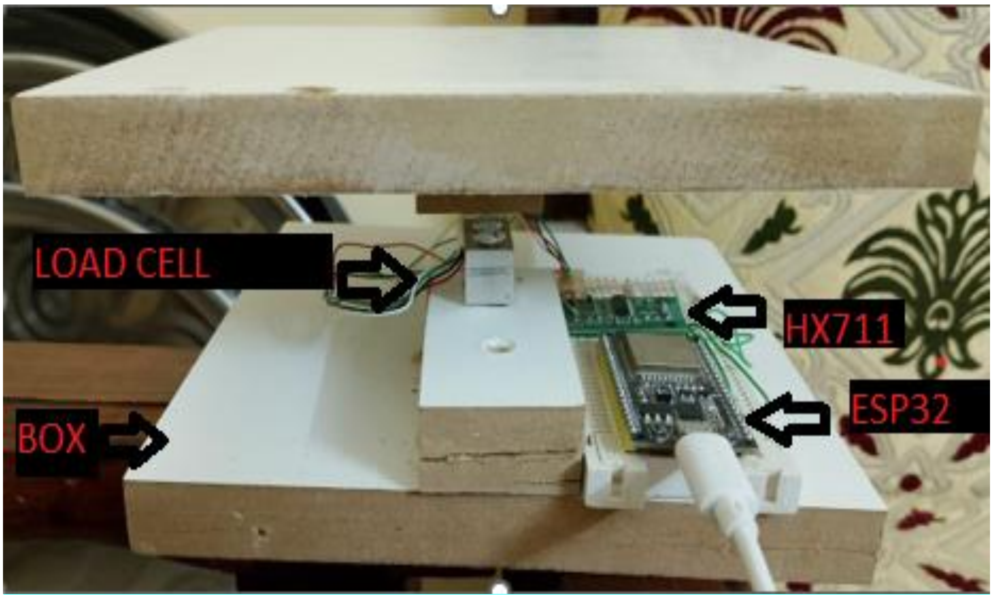

Figure . 3.9: Global System (Prototype)

3.8 Conclusion :

This chapter outlines the process of production and making a smart scale that aims to solve most of the problems surrounding weight and data monitoring with a focus on user convenience and reliability in data transmission. A board of ESP32 and a load cell sensor were used in designing an integrated measuring system. Electrical diagrams and practical implementation of the system were presented, along with real-life testing to prove its effectiveness.

Thereafter, a mobile app was developed with MIT App Inventor to provide an interactive interface. The app utilizes Firebase for real-time data display, which is easy to access and monitor remotely. The interaction among the ESP32, app, load cell sensor, and user were successfully tested to verify seamless integration among parts.

General Conclusion

In light of rapid advancements in electronics and communication technologies, improving quality of life through smart systems has become increasingly essential—particularly in the areas of health and accurate weight monitoring. This project aligns with that vision by designing and developing a smart scale integrated with an Android application to offer users a convenient, accurate, and safe experience.

The project centers on building a fully integrated system comprising a smart electronic scale capable of measuring weight and transmitting the data instantly to a custom Android application developed using the MIT App Inventor platform. The application uses Firebase Real-time Database to store and display data immediately, allowing users to track previous measurements and analyze their health trends in a simple, user-friendly interface. Additionally, the system supports remote access, making it suitable for long-term health and fitness monitoring.

Throughout the project, we explored key concepts of the Internet of Things (IoT) and the integration of smart devices with mobile applications. We proceeded to design the prototype, develop the electronic circuitry, program the application, and establish a live database connection. The result is an efficient, low-cost, and accessible solution for everyday health tracking.

Looking ahead, future developments will focus on expanding the scale's capabilities to include additional body composition metrics such as BMI, body fat percentage, and muscle mass. We also aim to enhance the app with personalized health insights, data visualization tools, and integration with popular fitness platforms like Google Fit or Apple Health. Furthermore, improving the design for commercial production, adding multi-user support, and implementing advanced security features will be key steps to allow the device to store data locally when offline and sync it to the cloud/app once connectivity is restored. Integrate advanced graphs and weekly/monthly summaries to help users track their progress over time.

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