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CYBER PHYSICAL SYSTEMS

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Group 2

IoT Project Proposal

Smart Kitchen Ingredient Dispensing System

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Introduction

The modern kitchen is increasingly becoming a hub of innovation, where automation and smart technology are improving efficiency and convenience. However, ingredient measurement and management still rely heavily on manual processes, which are time-consuming, error-prone, and hard to track. Our proposed Smart Kitchen Ingredient Dispensing System aims to address this issue by automating the dispensing of encapsulated ingredients with real-time control, data tracking, and wireless communication.

Problem Statement

In commercial kitchens, the manual process of collecting and measuring ingredients for each dish introduces inefficiencies, human error, and delays, especially during high-demand hours. This project proposes a cyber-physical solution: a smart ingredient dispenser system that automates the accurate and timely dispensing of ingredients based on pre-defined recipes.

The system consists of a central controller (Raspberry Pi or PC) that stores dish recipes and handles customer orders. Upon receiving an order, it wirelessly transmits the required combination of ingredients to a smart dispenser unit powered by an ESP32. The dispenser features motor-actuated, 3D-printed dispensing mechanisms for each ingredient bin, designed to deliver solid disc-shaped dummy ingredients representing real-world food items.

This setup eliminates the need for manual ingredient collection, ensures consistent quantities, reduces kitchen errors, and integrates seamlessly with modern smart kitchen systems.

Key Features:

- Centralized recipe management and wireless task distribution.
- ESP32-based control of actuator mechanisms per ingredient.
- Modular, 3D-printed dispensers for easy scalability.
- Focus on industrial relevance and automation within food-tech.

Objectives

The Smart Kitchen Ingredient Dispensing System is aimed at following objectives:

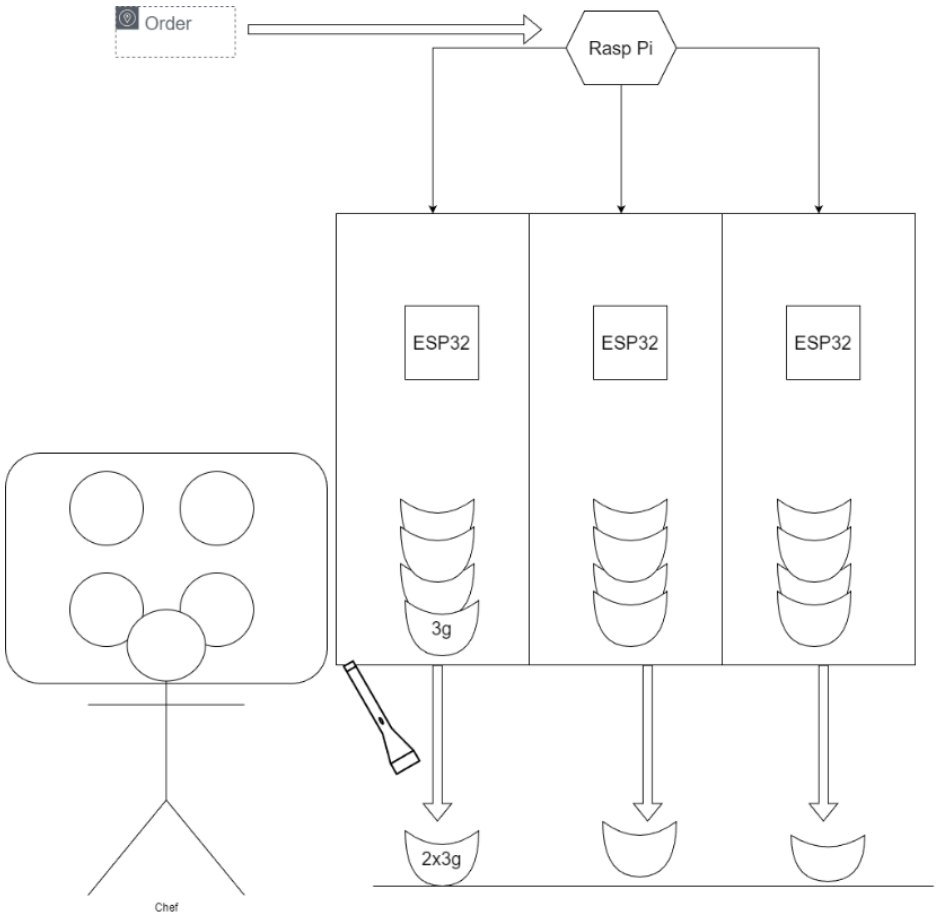
- Design, build, and demonstrate a smart ingredient dispenser that distributes encapsulated ingredients by units.
- Include sensors that detect whether the dispensing area is occupied and control it by queue.
- Integrate with an ordering system which communicates wirelessly with the dispenser to send orders and recipes.
- Build a controlling system to collect, save, and manage daily orders and ingredient consumption for restock and planning purposes.
- Evaluate the scalability of the system to support dispensing multiple ingredients.

Methodology

System Components

- Smart Dispenser Units
- Ordering and Controlling System
- Wireless Communication Layers

System Design


Order
Rasp Pi
ESP32
ESP32
ESP32
3g
2x3g
Chef

Smart Dispenser Units

A Smart Dispenser Unit is designed to distribute a single type of encapsulated ingredient, which comes with the following components:

A Physical Dispensing Mechanism:

The dispenser will be built using 3D printing, which comes with a container of encapsulated ingredients and a motor-controlled gate to release. The amount of encapsulated ingredients to dispense will be controlled either by a moving partition or times of gate operation. The final design may use servo or stepper motor for either a gravity-fed or other mechanism depending on the functionality and reliability requirements.

An Occupancy Detection Sensor:

The sensor will monitor the dispensing area to detect whether the container is ready to receive ingredients. This sensor might be either IR, ultrasonic, beam break, or a combination. The incoming orders will be queued until the dispensing area becomes free.

A Microcontroller with Wireless Connectivity:

The microcontroller of the smart dispenser controls the motor and sensor. This controller needs to be Wi-Fi or Bluetooth enabled to communicate with the central controlling system. ESP-32, HC-05, or Raspberry Pi will be feasible candidates.

Ordering and Controlling System

The Ordering and Controlling System is built to take incoming orders, handle ingredient queues, manage multiple dispensers, and collect operation data. It could either run over a laptop or Raspberry Pi.

Order Management:

A simulated order will be given to the system via Web Interface, Consol Input, or Coded Script to retrieve all meal items to kitchen.

Recipe Processing:

The controlling system will extract all ingredients needed for each meal item from the order and send them to the corresponding dispensers.

Multi-dispenser Coordination:

This controlling system needs to handle a global queue system when dispensers are not in synchronized state.

Wireless Communication Layers

The system will use **Bluetooth** or **Wi-Fi** for wireless communication between the controlling system and the dispenser units.

- Bluetooth may be used for local communication with paired devices.
- Wi-Fi (ESP32) is preferable for connecting multiple units over a local network and enabling remote access.

Data Storage and CPS Features

- **Sensor:** IR/Ultrasonic sensor for cup detection.
- **Actuator:** Servo/Stepper motor for dispensing mechanism.
- **Wireless:** Wi-Fi (ESP32) or Bluetooth (HC-05).
- **Data Storage:** Logged data will include timestamps, ingredient types, quantities dispensed, and errors (if any). This will be stored on a local SD card or sent to a cloud-based database.

Real-World Application

This project addresses challenges faced in modern kitchens, restaurants, meal-prep services, and catering industries. The system improves hygiene, consistency, and operational efficiency, while enabling smart inventory management. It can reduce manual labor, ensure precision in recipes, and enable data-driven ingredient planning.

Timeline

- **Week 1:** Finalized system design and assigned team responsibilities.
- **Week 2:** Design and 3D print the dispenser unit and begin assembling hardware components.
- **Week 3:** Integrate sensor and actuator with microcontroller and implement core dispensing logic.
- **Week 4:** Set up wireless communication and develop data logging functionality for order tracking.
- **Week 5:** Complete system integration, conduct full testing, and prepare final presentation and demo.