Robotic Application Development

Coursework

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RAD Coursework Report

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Declaration

I hereby certify that this project does not incorporate, without acknowledgment, any material previously submitted for a Higher Diploma or any other qualification at any institution. To the best of my knowledge and belief, it does not contain any material previously published or written by another person or by myself, except where proper reference is made within the text.

I further declare that all work presented in this report is my own, and I take full responsibility for its content.

I also give my consent, if this project report is accepted, for it to be made available for photocopying and interlibrary loans, and for the title and summary to be made accessible to outside organizations.

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Abstract

The project represents a design and a development of an automated fruit salad making machine. The weight sensor gives the correct amount of weight for the fruits you placed and the salt and sugar percentage will be calculated for adding and the two motors are controlled by a microcontroller to the Arduino mega board and for the cutting purpose a frame that withstand a wired squares are implemented and a motor will be pushed towards those frames. The prototype describes the way of making fruit salad automatically with a minimum amount of human labor.

Acknowledgements

The project has successfully finished execution and everyone who helped achieve this success receives our deepest gratitude.

We genuinely thank Mr. Supun our module lecturer for his beneficial guidance during the entire project duration along with his supportive role. The insights and motivation provided by him drove us toward achieving our goals.

The National Institute of Business Management (NIBM) serves as our heartful appreciation for delivering vital facilities in addition to essential resources. Our ability to effectively complete and develop the project improved substantially because of available technology and the environment of collaboration.

We want to express our respect for all members of our team because their continuous dedication along with teamwork enabled the ultimate success of this project. Our group members collaborated with determination to face obstacles before implementing an open-minded method that led to project success.

We express deep gratitude to everyone who assisted us at any point throughout this expedition.

Yours faithfully,

GAHDSE242F-004 H L L T ANUTHTHARA

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Introduction

1.1 Introduction to the Project

In the view of modern automation of food, the need for the efficient, clean, and easy to use kitchen appliances is constantly growing. The automated fruit salad making machine is one of such an innovation envisaged to simplify the healthy food preparation process. This machine is built to team up multiple functions into one compact unit that is designed to minimize manual labor and to deliver fresh and well mixed fruit salad with minimal human intervention.

1.2 Aim

The aim of this project is to limit the human labor that is used for fruit salad making for higher production by automating the whole process of fruit salad making from cutting the fruits to measuring and mixing.

1.3 Objectives

- Mix the right amount of salt and sugar
    - When making of a fruit salad you need to put the right amount of salt and sugar for every fruit salad you are making in order to get the same taste as the other fruit salads.
- Cutting fruit to same size
    - When the make of the fruit salad you have to cut perfectly sized fruits in order to get the beauty and the taste of the fruit salad so in this we aim to cut the perfectly sized fruits for each and every fruit.
- Display Progress
    - To show the user the whole progress of what happening we aim to provide the user with a led display that showcase the progress of the fruit salad making.

1.4 Scope

The machine has a pusher mechanism to drive the whole fruit in the direction of sharp cutting blades so that the cutting is precise and uniform. Once these cut fruits are delivered to the conveyor belt, there is a water spray system installed to rinse and freshen the fruits while in transit. After the fruit pieces are cleaned, they are given the direction of a bowl fitted with a weighing scale to obtain the accurate portion measurement. When the quantity of desire is achieved, the bowl, equipped with a motorized lid and bottom shaker mechanism, thoroughly mixes the ingredients until the fruit salad is ready to serve.

This machine brings a powerful set of smart kitchen solutions through combining mechanical design, food hygiene protocols and automation technologies. Not just to the convenience of household but also to the commercial quick serving places like restaurants, cafeterias and food truck that demand speed, consistency, and cleanliness in food prep.

Literature Reviews

Fruit Cutting Mechanism

Automatic Fruit Cutting Systems are typically optimized for speed and safety as it is very sharpened, and they are based on mostly rotary based mechanisms. In here for the fruit cutting mechanism, we use the Pusher Mechanism that guide the fruits towards a stationary blade.

According to Wankhede et al. (2019), the use of a motorized pusher increases precision and reduces the variability in slice thickness, especially in cylindrical fruits like bananas and cucumbers.

Rotating blades driven by motors are a proven method for producing consistent cuts in industrial environments. These mechanisms are often complemented by safety features such as blade guards and emergency stops (Jarimopas et al., 2008). To maintain the integrity of soft fruits it is necessary to maintain a proper blade geometry and speed.

Sources:

- Wankhede, V., Patil, S., & Bhoyar, R. (2019) Automatic Fruit Cutting Machine, International Journal for Scientific Research & Development (IJSRD), 7(2).
- Jarimopas, B., Jaisin, K., & Lertsatitthanakorn, C. (2008) Design of a coconut fruit cutting machine, Biosystems Engineering, 100(3), pp. 350-357.

Conveyor Belt and Water Supply System

For transporting the fruits between essential platform while minimizing the human impact it is necessary to install the conveyor belt mechanism than placing the fruits by hand. In a study by Oyeleke et al. (2014), the integration of water jets above the conveyor belt not only ensured efficient transport but also removed surface contaminants and maintained fruit freshness.

Hu et al. (2021) found that continuous water spray can prevent microbial growth while also enhancing fruit appearance before final mixing.

Sources:

- Oyeleke, O., Ogunleye, O., & Ajayi, A. (2014) Development of a Fruit Washing Machine, International Journal of Engineering and Technology, 4(4), pp. 227-231.
- Hu, Z., Huang, J. & Wang, Y. (2021) Development of a water-assisted conveyor belt system for cleaning fresh produce, Journal of Food Process Engineering, 44(7).

HX711 and Load Cell for Quantity Measurement

For achieving a standardized output, we need to measure out the accurate weighing of the fruits in order to provide enough ingredients to make the fruits salad more tasty. As the main part of measuring weights of the fruits HX711 act as the major sensor which process the weight according to the signals given by load cell. These devices provide high-precision weight data and can interface with microcontrollers or PLCs to trigger further processes once the desired weight is achieved (Patel & Shah, 2020).

The bowl has a mechanism to open or close the lid based on a single input signal to ensure that the fruit doesn't go away when mixing it all together at a decent speed. Esmaeili et al. (2021) highlight that closed-lid systems in automated mixers prevent oxidation and preserve taste.

Sources:

- Patel, N.K. & Shah, D.R. (2020) Integration of digital load cell systems in smart food processing units, Journal of Instrumentation and Control Engineering, 8(4), pp. 221–226**.**
- Esmaeili, S., Saeid, H., & Ahmad, M. (2021) Design and Assembly of An Automated Juice Mixing Machine, ResearchGate.

Mixing via Motorized Base

For mixing the fruits to maintain that it doesn't get crushed while mixing we can use a small vibration or shaking mechanism rather than using blades. According to Yamamoto & Hasegawa (2020), using a motor below the bowl to create oscillatory motion allows for gentle mixing of soft or delicate food items. When the motor is programmed with appropriate timing and frequencies it can lead to a better fruit mixing along with the safety of the texture of the fruit.

Sources:

- Yamamoto, S. & Hasegawa, M. (2020) Soft robotic systems for automated salad and fruit mixing in smart kitchens, Robotics and Automation in Food Systems, 5(3), pp. 67–74.

Automation and Control Integration

It is necessary for a central control system, typically made by a PLC or microcontroller based on interface, which coordinates cutting, transporting, washing, weighing and mixing. To achieve high operational precision and product consistency, sensor integration and real time feedback loops are also explained by Gursoy et al. (2023). Further example of an adaptation of an AI based system to autonomous food preparation and slicing tasks is the RoboChop framework developed by Dikshit et al. (2023).

Sources:

- Gursoy, M.E., Yildirim, M., & Kayacan, E. (2023) Vision-based dual-arm robotic fruit harvesting with soft end-effectors.
- Dikshit, S., Gokhale, N., Srivastava, N., Arora, A., & Patel, S. (2023) RoboChop: An autonomous framework for fruit and vegetable chopping using foundation models.

Methodology

System Overview

To make fruit salads more effectively and efficiently the automated fruit salad making machine will do an outstanding work through its mechanisms. From weighting the fruits to all the way to mixing them will function as below.

1. System protection.

- The system is encrypted by a password in order to prevent from unnecessary inputs towards the machine and once the password is set the system will be enabled.

2. Accurate Weighting

- After the system has been enabled the fruits can be placed in a scale made by a loadcell and a HX711 to get accurate weight readings and it has a automated taring function to tare the weight before placing another fruit and once they are placed we can calculate the necessary salt and sugar amount for the salad.

3. Pushing

- Later the fruits have been weighted we use a MG995 servo motor to push the fruits towards the cutter we have made by nylon threads.

4. Moving

- After the fruits have been cut perfectly the conveyer belt need to be started in order to travel the fruits towards the mixing bowl while washing them via a water supply we give towards the belt using an air pump.

5. Mixing

- Afterwards the fruits will be dropped to the mixing bowl via the conveyer belt for mixing and salt and sugar will be added as well.

Components

- Arduino Mega
    - Acts as the main microcontroller that controls the whole prototype.

Figure 1 - Arduino Mega

- Jumper wires
    - Used to connect microcontroller with each component.

Figure 2 - Jumper wires

- Motors
    - Gear motor for controlling the bowl and a 12v DC motor for controlling the conveyer belt

Figure 4 - 12v DC Motor

Figure 3 - Gear Motor

- L298N Motor Driver
    - Used to control the speed and the directions of the motors that is used for he conveyor belt and the mixer

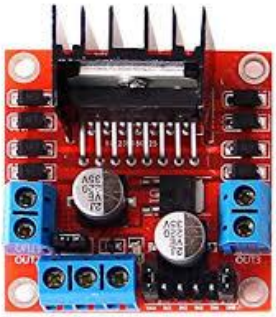

Figure 5 - L298N Motor Driver

- Loadcell
    - To make a voltage difference to get the actual weight of the placed object

Figure 6 - Loadcell

- HX711
    - Used to get the Calibration of the voltage difference made from the loadcell.

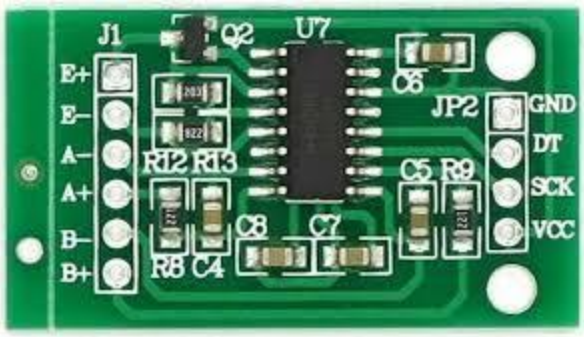

Figure 7 - HX711

- MG995 Servo Motor
    - For the pushing mechanism.

Figure 8 - MG995 Servo motor

Libraries

- #include <Keypad.h>
    - This library is helped to control the inputs of the 4X4 keypad using Arduino mega/uno.
- #include <Wire.h>
    - This library must be used when dealing with the liquid crystal library.
- #include <LiquidCrystal_I2C.h>
    - The liquidcrystal library is used to integrate the lcd display with the Arduino board.
- #include <Servo.h>
    - An inbuilt library that is used to control servo motors.
- #include <math.h>
    - Used for calculation purposes.
- #include <HX711_ADC.h>
    - Used to get the weight through calibration and connectivity from the HX711 module that is connected to the loadcell.

Design and Development

The Automated Fruit Salad Making Machine includes four main parts like weighting, cutting, moving and mixing. The weighting, cutting and moving parts are connected to a box made by hard board and the mixing is connected outside the box.

Apart from that all the micro controllers have been programmed with Arduino Mega via C++ using Arduino IDE.

Workflow

1. **Weighting:** The system weights the amount of fruits that is placed to the machine using loadcell that is connected to the HX711.
2. **Cutting:** The fruits make it way to the cutter by the push provided by the servo motor and will be cut into pieces when the fruits go through the cutter.
3. **Moving:** After cutting the fruits they directly fall down to the conveyer belt for transportation and also cleaning.
4. **Mixing:** Later when all those are done the fruits will be dropped to the bowl for mixing the fruits in order to get the perfect fruit salad.

Discussion

When developing both the hardware and prototype components regarding the automated fruit salad machine we faced some kind of problems while in the process of building it.

1. Power Distribution
    - The 5V output of Arduino board doesn't satisfy the necessary voltage when it was shared through multiple components.
    - By using 2*3.7V rechargeable batteries it decreases the voltage when powering up the MG995 servo motor and the power only last around like 5-10 mins.
    - When working with MG995 servo motor the power source must contain a stable 5V and 2A power supply in order to work perfectly.
2. HX711 Problems
    - The HX711 doesn't give the correct reading when it is connected via jumper wires to the connecters of the HX711.
3. Wiring Problems
    - The wires are sometime loosened and doesn't give the core performance for the component.
4. Lack of components.
    - It is hard to find the necessary components for the project, like HX711, MG995 servo motor.
5. Lack of Prototype Components.
    - Hard to find a belt that suits for the conveyer belt.
6. Making of the Cutter
    - First, we tried to make to cutter using a steel cage but while tensioning it the cage broke and we were out of option at that time and also the blades of the paper cutters were also not enough for the task because it was easy to be broken.
    - Afterwards we tried tensioning some thick wires and it also failed due to tensioning.
7. MG995 Servo motor
    - The MG995 servo motor needs a stable voltage of 5V and 2A. The 5V output of the Arduino is not enough for the MG995 servo motor and it acts weirdly when given power.

While we faced these problems we also came up with solutions for these problems and also some advice for the future researchers that they can prefer. Here are some of them,

- Always check all the ports of the Arduino board with a led before moving out for the whole project.
    - When you are doing the project first of all check if the Arduino board works perfect because some pins of the board may not work due to the previous usage of the students and for that always check before you come up with completing the circuit in the Arduino board.
- Always connect the loadcell to a support.
    - Don't test the loadcell in a flat surface because the loadcell use an angle like mechanism to give signals from the loadcell.
    - If you are using a flat surface to test the loadcell my advice is to not check like that. If you don't have a support place the two holes side of the loadcell to the edge of the table and give a pressure to the other side and then put on a weight to the two holed side of the loadcell.
- Don't use HX711 with connectors
    - If you are using a HX711 don't connect the connectors that come along with the HX711 to directly connect the jumper wires.
    - Solder the jumper wires directly to the ports of the HX711 without connecting via jumper wires.
- Give proper power distribution
    - To power up the Arduino board use 2*3.7V batteries and connect them to a power jack that can connect to the Arduino board.
    - Don't use the 5V output of the Arduino board to power up multiple components.
    - Give the required proper power distribution to all the components via an external power supply.

Future Implementations

- Fruit Peeling
  - The system can integrate with fruit peeling mechanism in order to save any human labor that goes towards the peeling process.
- Sanitizing the fruits and components frequently
  - To provide the freshest fruit salad by sanitizing the fruits and the components after each trial.
- Automated salt and sugar adding via a robotic arm
  - To prevent any human labor, you can implement a programmed robotic arm for adding the correct amount of salt and sugar to the fruit salad while it is in the mixing process.
- Detecting rotten fruits
  - Can Implement a system to detect any rotten fruits and distinguishing them in order to get the freshest fruit salad.
- Selecting the fruit automatically
  - By using a color sensor, you can implement a system to detect the fruit that needs to go through the making of the fruit salad.

References

- Pawar, K.R., Ukey, P.D., Bhosale, P.D., Ghorpade, K.B., Jadhav, R.B., Patil, A.A., 2020. Development of Fruit and Vegetable Slicing Machine. International Research Journal of Engineering and Technology (IRJET), 7(3), pp. 1282–1285.
- Talapatra, S., Shakil, M., Mondal, P.K., Islam, M.S., 2014. Implementation of Product Design Tools for the Development of an Automated Vegetable Chopper. Technology and Investment, 5(1), pp. 1–7.

Gantt Chart

TASK	Feb 23	Feb 23-25	Feb 25-28	Feb 29	Mar 20	Mar 27	Mar 28	Mar 29	Apr 1-10	Apr 11-15	Apr 16-22	Apr 22-28
Project initiation												
Research and planning												
Project components procurement												
Prototype Design												
Testing and debugging												
Documentation												
Final review and report												

Appendix

GitHub

- https://github.com/lasindu-themiya/Automated-Fruit-Salad-Making-Machine.git