PROPOSAL FOR MULTI-PURPOSE AUTOMATED ROBOTIC ARM

PROJECT PLAN

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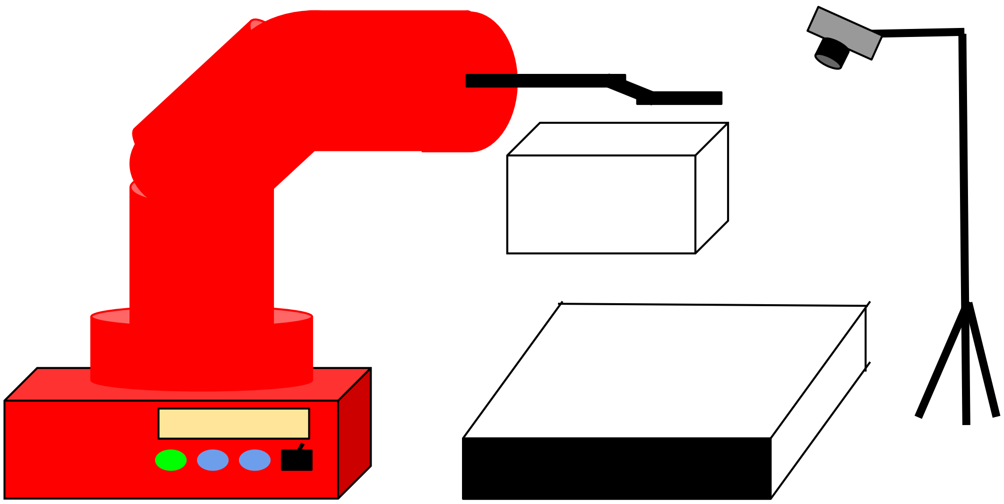

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● ISU: An acronym for Iowa State University

● Computer Vision: A technology which allows a computer to receive information from a camera or similar device and process that information in such a way as to interpret it and produce a response accordingly

● Iowa State: An abbreviation for Iowa State University

● mpARA : Multi-Purpose Automated Robotic Arm

1 Introductory Material

1.1 Acknowledgement

The Multi-Purpose Automated Robot Arm team would like to kindly thank Professor Stoytchev for allowing members of our undergraduate team to participate in his graduate level course on computer vision which greatly our team the ability to develop our vision into a reality. Additionally, we would like to thank Iowa State University for providing the necessary funding for our team and allowing us to utilize a wide range of campus resources over the course of the project development phase. (Note: Credit Arm Designer).

1.2 Problem Statement

As a result of increasing production costs for food related products in the restaurant industry coupled with work related injuries in the kitchen and a lack of product consistency, both the producer and consumer are negatively affected. Producers are forced to increase costs to deal with an ever-increasing wage as well as covering medical expenses for injuries sustained in the workplace. As costs increase so does the price of the goods the consumer purchases. Consumers must also accept that at times as a result of human error on the cook's behalf, the food they get might be inconsistent with previous experiences at the same establishment.

To combat this issue automation in the form of a robotic chef will need to be implemented in the workspace. While the end goal is to produce an automated system, which could produce a variety of different menu options, our team will be solely focusing on the production of pancakes as a proof of concept. Equipped with multiple arm utensils coupled with computer vision, this system will be able to perform the same tasks as a human cook and more. An automated cook could work highly efficiently and would require no breaks, not suffer from fatigue and create a consistent product every time. With the implementation of an automated chef arm the cost of labor included in preparing the food could be greatly reduced.

1.3 Operating Environment

The intended operating environment for which this product is being designed to function in is that of an industrial and home grade kitchen. One type of condition in which this product will need to withstand is intense heat produced from the oven, grill or fryer. In kitchen like conditions it is also expected that condensation from water evaporating in a pot to the dishwasher running is to be present. It is also likely that human employees will be occupying the space alongside the robot in the kitchen. Kitchens are at the best of times sanitary stations but are environments where incompatible components have the potential to mix resulting in sickness and occasionally death. Understanding the type of environment our product is to be placed in is not only important so as to design a robust system to withstand the hazards in the environment, but to uphold the environments sanitary conditions to promote a safe product.

1.4 Intended Users and Intended Uses

Project mpARA aims to modernize the cooking experience in both a professional and home environment. Therefore, mpARA will have two primary users: restaurant employees who regularly work alongside and interact with the system in the workplace and the everyday person looking for assistance in preparing meals in their own home. While the primary objective of both users is similar the two groups will expect different end results as their needs are slightly different from one another.

On a commercial scale restaurant employees will require the ability to produce a handful of carefully crafted recipes quickly and efficiently. While having the ability to perform a lot of tasks is important it is just as important to deliver a product that is consistently good as well as quickly produced. In such environments it is unlikely to find a single employee performing all the tasks as it results in a bottlenecking of the system. It is much more common place to see a variety of workers working at a set number of stations in unison to produce a variety of dishes at an intense speed. It is necessary that individuals working in a commercial kitchen keep in sync with one another so as to not disrupt the flow of food leaving the kitchen. These employees and effectively our users will expect that whatever system is provided to them that it does not hinder the system they have already established but enhances it.

Everyday people preparing food for themselves in their homes operate on a whole other system entirely compared to restaurant employees when making food. These individuals likely require a variety of different food options when compared to restaurants and require the ability to make a dish from start to finish at a single station with little to no assistance. Speed is just as important for the individual at home as it is for the team working in an industrial kitchen. These users require a system that provides little effort compared to the product to which they are receiving. Moving forward will require a system at for little to no manipulation can accomplish both methods to produce a meal.

1.5 Assumptions and Limitations

Assumptions:

- The input product such as batter, sliced fruits and toppings will be similar in size shape and their location to station is consistent.
- Once the system is programed to work in certain conditions those conditions remain the same. Example would be once the robot gets use to the height of a stove top the user doesn’t change it.
- The location of the pancake once the batter has been poured remains the same
- If any additional tools are required to prepare the dish, those tools remain in designated locations

- The locations where the dish is being outputted to remains the same and unchanged
- Robot will be constantly fed required inputs such as batter and will not be required to prepare its own.

Limitation:

- The system will require users to dispense required materials such as pancake batter.
- The cost of the unit has to remain under $1500
- Set of required space must allow for a robotic arm to fully maneuver
- System will assume that it will be provided with the required materials. For example, if the user placed materials for making burgers, but selected the pancake setting the robot would assume that the materials placed in zones corresponds to making pancakes not burgers.
- System will assume systems like the stove top are properly prepared and ready to perform desired tasks upon

1.6 Expected End Product and Other Deliverables

– Delivery dates shall also be specified.

The final product will be split into two parts. the first step is to produce a mechanical system that can reliably and accurately produce the desired product. The second part is comprised of computer learning system which can determine the status of the dish. When in unison the system will be able to determine the status of the dish and act accordingly so provide the perfect product on a consistent basis. The final product should specialize in the industrial environment, but should be applicable in a household system. Consideration should be taken in regards to the power as a standard 120 volt power supply should be applicable to all models.

Prototype - December 6th, 2019

- The prototype will be a proof of concept and will consist of a rough design 3D printed robotic arm with basic motion abilities. At this point the computer vision is unlikely to be completed, but the physical design should be well on the way.

April 27, 2019

- The system should be able to fully function on both a physical and logical level.

· Project Proposal Accepted

o Expected Delivery Date: 1 Month

o Description: The proposal is accepted, and the project can continue.

· Demonstrate a responsive user interface o Expected Delivery Date: 6 Month

o Description: The chassis will be assembled by then and the beginning of the software program will be tested.

· The mixture is poured properly onto the flattop.

o Expected Delivery Date: 7 Month

o Description: The robotic arm will be assembled with working stepper motors and encoders, demonstrating controlled pre-planned movement from one position to another.

· Computer vision system detects when a pancake is ready

o Expected Delivery Date: 8 Month

o Description: The computer will be connected to the camera and be able to tell when the pancake is ready to flip via analyzing the surface bubbles on top of the cooking pancake or reading the internal temperature utilizing an infrared camera.

· The robotic arm can move on demand and flip a pancake

o Expected Delivery Date: 9 Month

o Description: The robot arm can move quickly enough to flip a pancake in the same place with demonstrated efficiency.

· Pancakes are made

o Expected Delivery Date: 10 Month

o Description: The entire system is working properly together, where users are able to submit their request, and have it served to them a set amount of time later.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

We will produce a working prototype of a machine which can automatically make pancakes (and in principle other foods as well). We intend it to take the form of a robotic arm which is enabled with computer vision and other technologies. It will be a proof-of-concept work which could show potential applications in the foodservice industry. It will be a physical machine, electrically powered, and incorporating some 3D printed parts.

2.2 Functional Requirements

This machine will:

- efficiently, automatically, and uniformly make pancakes

- be safe for all people who come into contact with it and with what it produces

2.3 Constraints Considerations

List and explain the constraints and non-functional requirements of the project. This is where you would enlist non-technical requirements. This may still be a fundamental deliverable that your client needs at the end of the semester.

Discuss the **standard** protocols that you follow in your lab or for writing code. Are these approved by standard organizations like IEEE, ABET etc. Will any of your practices be considered unethical by such organizations? Discuss how standards are applicable to your project.

2.4 Previous Work And Literature

Include relevant background/literature review for the project

– If similar products exist in the market, describe what has already been done

– If you are following previous work, cite that and discuss the **advantages/shortcomings**

– Note that while you are not expected to "compete" with other existing products / research groups, you should be able to differentiate your project from what is available

Detail any similar products or research done on this topic previously. Please cite your sources and include them in your references. All figures must be captioned and referenced in your text.

2.5 Proposed Design

The possible design solutions are endless. The ones that we discussed as a team are a robotic arm that will flip the pancake on a griddle or the arm jabbing a pancake out of a special pan. We also discussed a conveyor belt option that we decide would cost too much and not favor what we are trying to do in this project.

2.6 Technology Considerations

The reason we decided to use the robotic are is because of the thor arm and the abilities that that resource comes with. The thor arm is easy to make, 3D printing the parts and it has a data sheet so that the interfacing with this product will be smoother. A trade off to this is that the 3D printing process may be difficult for us to do because we may not have access to one when we need to use it.

The conveyor belt would be a simpler design, but the trade-off for this is that it would cost more for the belt system and it would not show off the strength of the team.

2.7 Safety Considerations

Some safety issues that come up are that the fire safety that comes with any item that uses electricity, the swing of the arm in the area the pancakes are cooking and the heat source not hurting anything around this product.

2.8 Task Approach

Our work approach entails a divide-and-conquer strategy. We have defined each team member's role according to their educational background and interests. The project is then divided into sub-parts and each person (or a group working collaboratively) accomplishes the related task. Then the people come together and synthesize what they have and the next round is started. In this way we plan to accomplish this task.

The team thus breaks down into individuals who work within their realm of experience and work in tandem with each other. Often times these individual domains overlap, allowing opportunities for two- three- and four- man subgroups to form.

2.9 Possible Risks And Risk Management

We are uncertain about how much our budget is realistically, especially in relation to the expense of certain components we would need to purchase. Also, there exists a concern about the amount of time the project will require. These are relatively minor concerns, but they nonetheless ought to be addressed.

2.10 Project Proposed Milestones and Evaluation Criteria

Key milestones for this project shall include a set of blueprints, then a series of tests on pancake recipes, electro-mechanical subsystems, a built working model, and finally a functional prototype. The tests we shall perform will be designed to show us whether or not a particular design or implementation satisfies our needs. This is relative to criteria and constraints we will define ahead of time. For example, we will develop parameters for the flavor, thickness, and batter viscosity of our pancake batter. Then we will see how that affects a batter delivery system and its contingent pump, valves, tubes, etc.

2.11 Project Tracking Procedures

We will have weekly meetings which will allow us to give an update to each other and to the faculty advisor. We use Slack and email which allows us to have well-documented communication, including deadlines and timestamped confirmation of a task being completed. A timeline of the project exists for the purpose of allowing us to see where we are in relation to where we planned to be time-wise. Also, we produce a weekly report which summarizes such information. We have started these processes now and plan to continue these strategies through the end of the project.

2.12 Expected Results and Validation

The desired and expected result of this device is that upon providing it with pancake batter and powering it on, it will yield a batch of pancakes which are of a uniform and desired shape, size, and level of doneness. Our solution will have accomplished these goals at a high level if it does them consistently over a long period of time with minimal messiness.

2.13 Test Plan

Testing will commence in two realms. The first is the information realm in which we will debug and compile our code. The second is the physical realm, in which we will test the robot's electrical and mechanical systems and troubleshoot the pancake-making process. We intend that the testing process will be iterative.

Firstly, early models and prototypes of subsystems of the larger whole will be constructed. From the information gained from these things we shall progress to assembling the complete robot. In that phase the testing will include a more high-level approach. This would include fine-tuning the pancake-making process.

It is anticipated that activities preliminary to testing will commence before the end of this semester. It is conceivable that early testing could even begin before next semester begins.

The second semester will be very testing-oriented. This will allow us to apply the scientific method by testing hypothesis multiple times and adjusting variables accordingly.

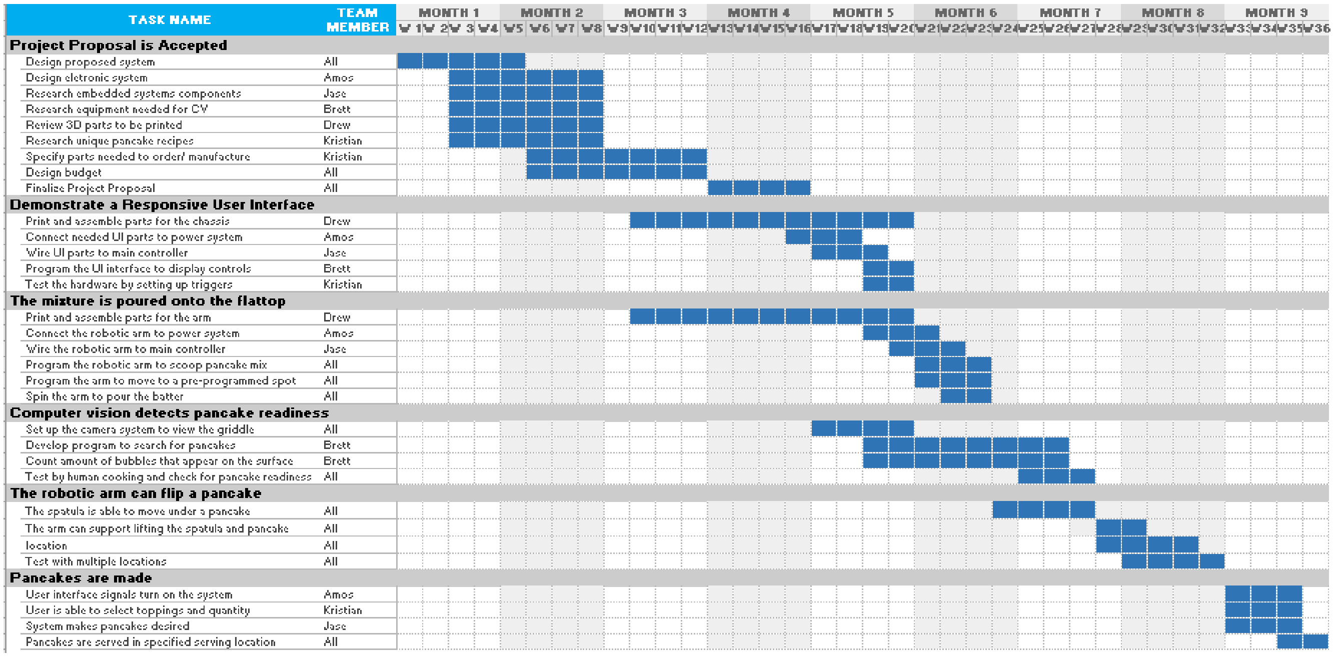
3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

A realistic, well-planned schedule is an essential component of every successful project. Most scheduling errors occur as the result of either not properly identifying all of the necessary activities (tasks and/or subtasks) or not properly estimating the amount of effort required to correctly complete the activity. The planning process and the beginning of the 3D printing will initiate during the first semester. Each person will be required to document what parts they will require to complete their section of the mechanical system. The 3D printing will require reserving space and time in the Design building. The larger parts of the arm will take upwards of 20 hours to print one section. The second semester will consist of assembling the mechanical system, developing the software and embedded system programs, and finally testing each part multiple times.

The following gantt chart will show the subtasks and time needed to complete each of the deliverables on the left hand side. The planned time for each of subtasks was made by selecting team members based off their given role and when they would be available to start the next task. As the team approaches the planned subtasks, the tasks are subject to change as we deem necessary in order to accommodate any problems encountered or tasks completed early.

Make sure to include at least a couple paragraphs discussing the timeline and why it is being proposed. Include details that distinguish between design details for present project version and later stages of project.



3.2 Feasibility Assessment

Realistic projection of what the project will be. State foreseen challenges of the project.

This project seems quite feasible, although there certainly may be difficulties. We foresee potential challenges with budget, getting in to 3D print our pieces when we need to print them and having to learn new programs in time to be efficient in them.

3.3 Personnel Effort Requirements

Each member will nclude a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be based on the projected effort required to perform the task correctly and not just "X" hours per week for the number of weeks that the task is active. We might also use trello or a way to track the tasks that are done or being worked on throughout the project.

3.4 Other Resource Requirements

- 3D Printer
- Griddle
- Motors for arm, servo motor for hand
- Chips (FPGA)
- Solder and wire.
- Motor modulation

3.5 Financial Requirements

The total financial resources that are required for this project is our budget of $1000 and what every we chip in as a group if it were to come down to it.

4 Closure Materials

4.1 Conclusion

In conclusion, the team is making headway in developing a mechanism able to optimize efficiency and consistency of modern day cooking and save the consumer time. The mpARA will be able to make pancakes at the touch of button and on completion serve the food on a platter. This product is implementable in modern day smart homes and will increase Smart City's reputation and market value. As the project continues the team will gain insight in the project progress.When building the product, a comprehensive list of resources used to develop this project will be compiled. This list will grow into the second semester. In the end we hope to develop a device which both solves the increase in restaurant costs while providing everyday consumers with the ability to elevate themselves from the pains of cooking and instead focus their time on more meaningful tasks.

4.2 References

http://thorrobot.org/

4.3 Appendices

Not yet established