CprE / EE / SE 491
Team MAY14-07
3D Printer Software Programming
Project Plan

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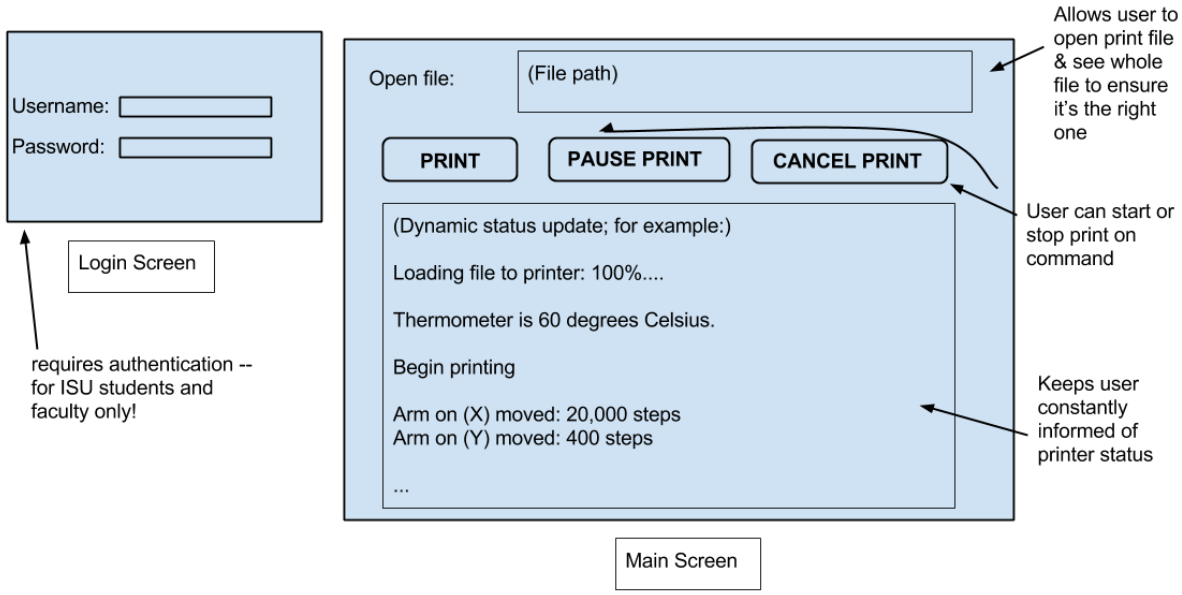
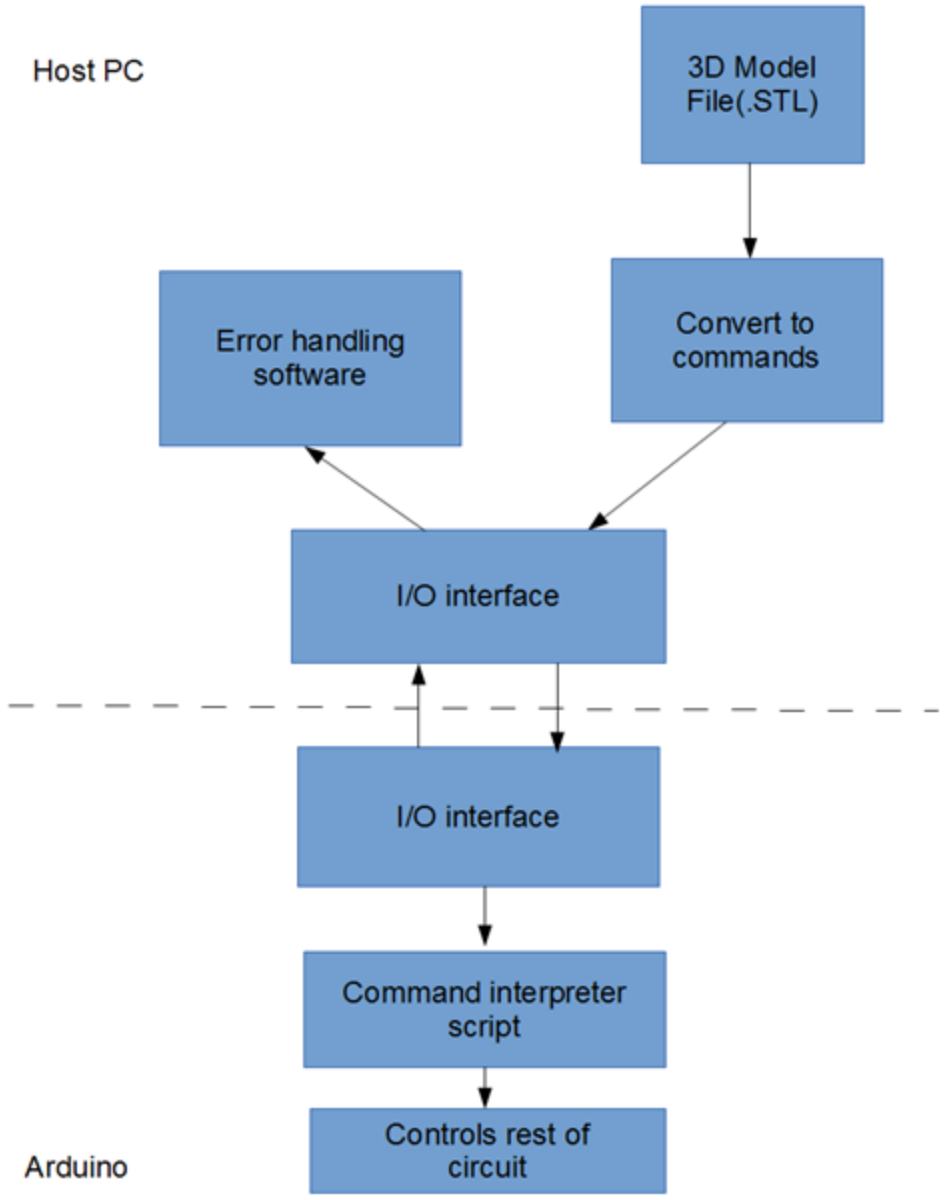
I. Problem Statement

Our teams need to create software for a 3D printer that will input a 3D model file and output an plastic model item through a 3D printer. We will need our software to effectively partition the parts of the model so that they may be effectively used by the model of the 3D printer. We also need to ensure that the 3D printer's software will be able to communicate effectively with the hardware, including the 3D printer, the Arduino DUE it's connected to, and a thermometer. The goal is to produce an object that will meet quality standards and be printed to specification.

II. Concept Sketch



III. System Block Diagram



IV. System Description

The system is a large 3D printer that weighs approximately 100 pounds. The printer can move along the X, Y, and Z axes. Attached to one of the arms is a nozzle, which can spray heated plastic onto a plate in order to print an object. The object is printed by utilizing a desktop computer. The software for the system will allow the user to select a 3D model file, which,

after running it through the program, will output as 3D object by the printer. The printer will print over a heat plate, which will heat or cool to an appropriate temperature depending on what the printer needs to successfully print the plastic model. The temperature of the heat plate will be monitored by a thermometer, which will send dynamic updates to the program.

V. Operating Environment

The operating environment is currently within the Senior Design lab, although upon its completion, it will likely be moved to another spot in a secure room within a building on the Iowa State University campus. It is expected that the room will be well-ventilated so that the components do not overheat, and will be kept reasonably clean so that there are not dust problems.

The program itself operates on a Windows XP 32 or 64-bit desktop that can edit and control the printer via a C++ interface. The results of the C++ program, consisting of input of a model file and an output of the printer arm's movement, status, any necessary temperature adjustments as well as printing adjustments based on temperature, as well as errors, will be given to the printer via a USB cable.

VI. User Interface Description

The user interface shall allow the user to browse their computer and select a model file. Once they select the model file, the user will be presented with additional options for their model, such as resolution. Once the user tells the program to print the model, they will be given dynamic information on what the printer is doing and the progress it has made on printing the object. The user interface will also provide information on the current temperature of the heat plate, and whether printing needs to be paused based on the temperature. The program will allow another model file to be selected once the first model file is finished printing.

VII. Functional Requirements

- The product shall take as input a model file that is compatible with our program, and will otherwise produce an error.
- The product shall determine a path that the printer nozzle can take in order to print the 3D object.
- The product shall produce a path for the printer head to follow.
- The product shall send the information of the printer head path to the Arduino DUE via USB.
- The product shall only accept one model file at a time.
- The product shall not allow the user to manually move the printer via commands excepting maintenance and calibration.
- The product shall be able to pause printing if there is inadequate filament and allow the user to replace the filament cartridge.
- The product shall allow the user to cancel the print job at any time.
- The product shall print the plastic model file onto a heat plate.
- The product shall only print when the heat plate is hot enough for the print job to be successful and without significant error.
- The product shall regulate the temperature of the heat plate.
- The product shall give power to the heat plate if it is deemed to be under a printable temperature.
- The product shall reduce power to the heat plate if it is deemed to be over a printable temperature.
- The product shall pause printing if the heat plate is too cold or too hot until it is back within an acceptable temperature range.
- The product shall inform the user if a temperature adjustment is being made.

VIII. Non-Functional Requirements

- The product shall take the average user no longer than 10 seconds to figure out the interface.
- The product shall produce an error message due to software programming during no more than 10% of usage time over a 3 month period.
- The product shall be easy to use by anyone with at least a high school understanding of English.
- The product shall be easy to use by someone who has had no

more than 6 months of exposure to computers.
- The product shall take no more than 10 seconds to complete the path finding algorithm per layer and send it to the Arduino DUE.
- The product shall produce a faulty print during no more than 5% of usage time over a 3 month period.
- The product shall not allow a model file over 1 GB.
- The product shall always clearly warn users of the safety concerns of utilizing the 3D printer.
- The product shall provide clear instructions for preparing the printer hardware.
- The product shall only allow Iowa State University students and faculty access to printing, and will therefore always require authentication.
- The product shall display the current temperature of the heat plate on the user interface screen 90% of the time.
- The product shall take no more than 10 seconds to read input from the thermometer.
- The product shall always clearly warn users of the safety concerns of working with the heat plate.
- The product shall not allow the user to manually adjust the thermometer.

IX. Market and Literature Survey

We have found through our research of the 3D printing software industry, with opinions from both professionals and users that, currently, 3D printers are still not a very established domain in the world of computers. Subsequently, while there is some software for it and it may seem some use, the resources are spread much more thinly than for more established practices.

The main selling point behind 3D printers is that they are able to produce items very cheaply. As was stated in the first source, while it is under scrutiny, people are exploring 3D printers as a way to be able to cheaply manufacture items here in the United States. That could lead to economy

and growth in our industrial sector.

3D printers have a wide variety of applications, from printing items for leisure to printing for practical purposes, such as medical devices. A complex piece of hardware such as a 3D printer needs strong software behind it to drive it. The machinations of a niche number of 3D programmers is available on the Internet for research and scrutiny; however, these sources are not as widely available as other well-known software enterprises.

Overall, we feel that a 3D printer would be a profitable and academically enriching venture. Due to the niche corner 3D printing software holds in the market, we may find ourselves pioneering some 3D printing methodologies or points of consideration, even if they are small.

Sources:

- http://readwrite.com/2012/07/03/how-open-source-hardware-is-driving-the-3d-printing-industry
- http://www.infoworld.com/d/computer-hardware/making-it-real-3d-printing-208721
- http://tech.slashdot.org/story/13/04/27/218250/whats-holding-back-3-d-printing

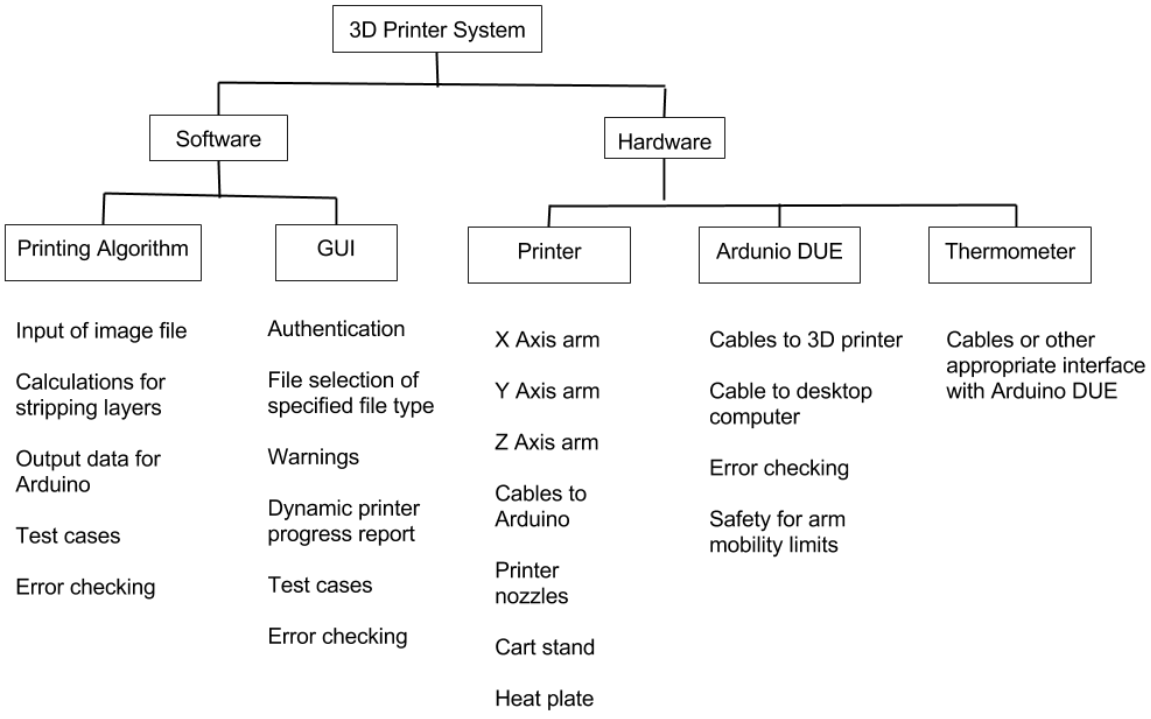
X. Deliverables

We will deliver a program that will control our 3D printer. The program will interface with the printer and send data that will allow the printer hardware to produce a 3D object. We will also deliver a specification on how to control the device and how to control the printer both with and without the driving software.

In addition to the ability to print, we also plan to deliver a calibration program for the 3D printer that will allow us to run each arm numerous times in a simple geometric pattern and accurately conclude whether the stepper motors that control the machine produce incorrect results after a large number of iterations.

XI. Work Plan

i. Work Breakdown Structure



ii. Resource Requirements

In order to do our project to the fullest, we must have the following:

- Desktop computer
- Arduino DUE board
- 3D printer attached to sturdy cart
- Peripheral electronics to run 3D printer
- USB cable to communicate between Arduino and desktop computer
- Serial port communication and programming software
- Thermometer
- Interface between thermometer and Arduino DUE

· Project Schedule

<u>Week of 8/26</u>

- Form teams and decide on project

Responsibility: Arielle, Piriya, Albert,

Wanting

Week of 9/2

- Perform research on 3D printers, microcontrollers, and Arduino boards to better understand project scope.

Responsibility: Arielle, Piriya, Albert, Wanting

Week of 9/9

- Continue research on hardware and software

Responsibility: Albert, Wanting

- Begin meeting with client in order to discuss their visions for project.

Responsibility: Arielle, Piriya

Week of 9/16

- Determine how to give both teams necessary access to 3D printer and how to best store the hardware to keep it safe and in good working condition.

Responsibility: Arielle, Piriya, Albert, Wanting

Week of 9/23

- Keep communication with Team 06 (partner team) open and determine anticipated problems and concerns and how to mitigate them

Responsibility: Arielle, Piriya

- Figure out how our teams intersect.

Responsibility: Arielle, Piriya, Albert, Wanting

Week of 9/30

- Receive code from professor in order to begin work on 3D printer

Responsibility: Piriya

- Set up a time to get a full demonstration of how the code works and what the system is meant to do

Responsibility: Arielle

- Determine necessary standards we may need to follow.
    Responsibility: Albert, Wanting

Week of 10/7
- Dedicate work to project plan
    Responsibility: Piriya, Albert

- Continue requirements gathering process and continue examining code to determine its functionality and features.
    Responsibility: Arielle, Wanting

Week of 10/14
- Continue requirements gathering for design process
    Responsibility: Arielle, Wanting

- Finish securing access to laboratory so both teams can work on the machine
    Responsibility: Piriya

- Compare project plans with Team 06 to eliminate discrepancies
    Responsibility: Piriya, Albert

- Work on design document.
    Responsibility: Arielle, Albert

Week of 10/21
- Finish design document
    Responsibility: Arielle, Wanting

- Further examine provided code and gain working understanding of logistics of printer software
    Responsibility: Piriya, Albert, Wanting

- Finalize printer hardware.
    Responsibility: Piriya, Albert

Week of 10/28

- Get administrator access to our lab computer so that we can download the requisite software for interfacing the 3D printer.
    Responsibility: Arielle

- Continue working on prototype
    Responsibility: Piriya, Albert, Wanting

Week of 11/4
- Contact CSG and Jason Boyd to finalize administrative access to computer
    Responsibility: Arielle

- Attempt to interface machine with Ubuntu while administrative access is uncertain.
    Responsibility: Piriya

- Write a prototype program for calibration automation to be immediately put to use once problems are solved with access.
    Responsibility: Albert, Wanting

Week of 11/11
- Work on formulating the website for our project and uploading documents to showcase what we are planning to do and what we have currently down.
    Responsibility: Arielle

- Work on and finalize project plan revisions.
    Responsibility: Arielle, Piriya

- Write full pseudocode for calibration program.
    Responsibility: Albert

- Understand what we have been doing in full due to being out of the country.
    Responsibility: Wanting

Week of 11/18
- Begin revising design document
    Responsibility: Arielle, Piriya

- Upload revised documents to website
    Responsibility: Arielle

- Begin base implementation of calibration program.
    Responsibility: Albert, Wanting

Week of 11/25
- Thanksgiving Break is this week which may make progress difficult since none of our team members will be on campus; continue revising design document and project plan, and think on solutions to any problems that may have occurred.
    Responsibility: Arielle, Piriya, Albert, Wanting

Week of 12/2
- Make final revisions to design document and project plan
    Responsibility: Arielle, Piriya, Albert, Wanting

- Continue implementation of algorithm into hardware components
    Responsibility: Piriya, Albert

- Begin designing user interface
    Responsibility: Arielle, Wanting

- Prepare for presentation.
    Responsibility: Arielle, Piriya, Albert, Wanting

Week of 12/9
- Continue implementation of algorithm into hardware components
    Responsibility: Piriya, Albert

- Show user interface to client to ensure that interface matches vision of product.
    Responsibility: Arielle, Wanting

Week of 12/16
- Finish revising design document and project plan

Responsibility: Arielle, Piriya, Albert, Wanting

- Continue implementation of algorithm
  Responsibility: Piriya, Albert

- Continue working on user interface
  Responsibility: Arielle, Wanting

- Make plan to decide which items may be considered over Winter Break.
  Responsibility: Arielle, Piriya, Albert, Wanting

- Make final updates to website for the semester.
  Responsibility: Arielle

Risks

- Communication is required between two teams, so progress could be significantly halted if there is a communication breakdown.
- Aspects of each team's project depend on the other team completing their projects, so if one team has a problem, the other team will find their progress significantly slowed.
- The 3D printer is very expensive, so if the 3D printer becomes unusable, our project will no longer be viable.
- The 3D printer is very heavy, so if the printer goes off balance or otherwise is removed from its usual state, it could cause injury.
- The budget for our project is small and we have not yet determined the required costs, so there may be constraints on the amount of money we have available.
- The full capabilities and limitations of the hardware are currently unknown, which leaves the reliability and precision unknown.
- The thermometer may have difficulties interfacing with the hardware, which will render the heat plate unusable.
- The thermometer may have a communication breakdown with the Arduino DUE during a print, which if not quickly resolved, may ruin the print.

- The heat plate may take a long time to adjust temperature, which could add a lot of time into the print job.
- If the heat plate's temperature is too extreme, it may ruin what has already been printed, and the print job would have to be restarted.