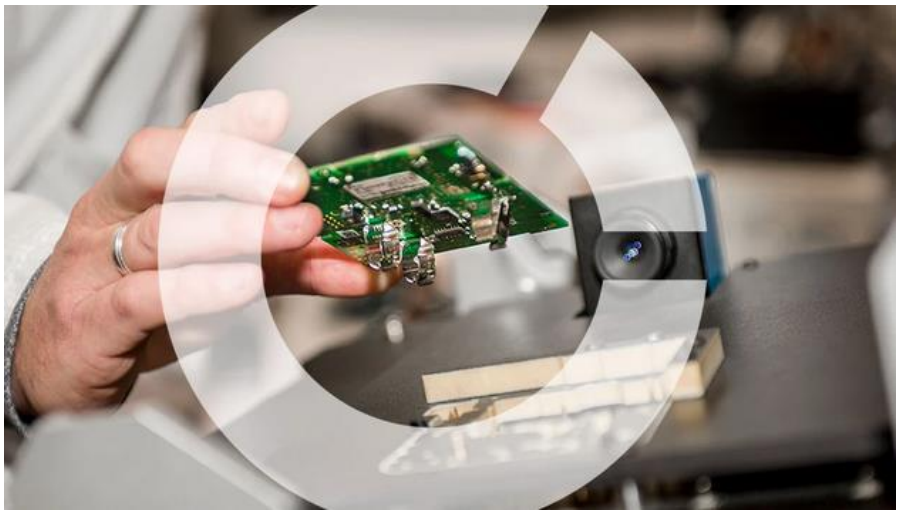
System Design Document

<simplified version>



Note: yellow marked text are guidelines, be sure to remove them from your final document before submitting.

Project name: *CNC machine*

Team name: *Plantastic*

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Document status: *Draft*

1 Content

2 List of tables

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Figure 5: an example of a “state machine” diagram, replace your own diagram here10

4 General info

Table 1: Document history

Version	Author	Date	Description	Status
1.0	Tevin	2/22/2024	Added the introduction, system overview and requirements	Draft

Table 2: Terms & abbreviations

Terms & abbrev's	Description
Aka	Also known as
DOTF	Development Oriented Triangulation Framework
Duration	Number of hours/days it will last until your activity is completed, aka lead time
Effort	Number of hours/days you will really spend to execute an activity
Ex.	Example
MoM	Minutes of Meeting / Meeting notes
MoSCoW	Acronym which defines priorities: Must - Could - Should - Would
PID	Project Initiation Document (=PP)
PoC	Proof of Concept (=prototype)
PP	Project Plan (=PID)
SDD	System Design Document
Sprint	SCRUM period of 2 or 3 weeks
Status - Draft	The user story is still under construction, no intention to be complete/final
Status - Proposed	The user story is assumed to be complete/final but still needs approval from customer
Status - Accepted	The user story is complete/final and approved by customer
US	User Story
CNC	Computer numeric control
Machining	Machining is a manufacturing process whereby a desired shape or part is achieved by the controlled removal of material from a larger piece of raw material by cutting
CAD	Computer-aided design
CAM	Computer-aided manufacturing

5 Introduction

The purpose:

This project is a computer numerical control (CNC) which is the automatic use of a tool by a computer. This CNC Project transforms any wood or piece of paper into a piece of art. We will use a flat version of a CNC machine which is the plotter.

This CNC project does precise movement that it will be computing and unlike traditional methods of crafting, which usually requires a lot of time and handwork, can just be automated using this CNC machine using high quality accuracy and time saving.

The components:

The machine will have a lot of components that will be explained further down below as we go but for now two major tools will be a Dremel and a pen that will be utilized for the drawing/carving. The system will instruct them to put the designs on to the chosen material like a paper or tool.

There will also be the use of various mechanisms like y, x and z axis movements for this project to make the precise movement possible. We will use software languages to guide most of the components.

The conclusion:

In this project the goal is to fuse technology and artistic craftsmanship so that artist can do more without the hindrance of manual labor. As we delve deeper into this system document it will guide you to the design, functionality, applications and laying the blueprint for a detailed understanding of its capabilities and structure.

6 System overview

Rationale: To provide the reader of this document with a high-level overview of the system and list its main features.

The system that we will be designing and building throughout this project will be easy to operate, have a small footprint, and thus will be approachable for home use. The features that will be worked on and included on the final product are as follows: A easy to use application to upload your design, watch and follow a live camera feed so you can see the progress made, a lighting system that will light up the worktable, a safety enclosure to protect the user from any flying debris, and of course it will be able to machine a piece of wood.

Table 3: main features

Id	Feature	Short description
	Live camera feed	The camera will be positioned inside of the safety enclosure to give the user the option to follow what the machine is doing.
	Temperature readings	Temperature readings will be taken from components that will be generating heat, with those reading the fan will speed up and keep the system in operating temperatures.

	Safety enclosure	To keep the user safe, there will be an enclosure built around the machine to catch any flying debris.
	Enclosure lighting	Because the camera feed is positioned inside the safety enclosure, the worktable will be dark, to ensure the camera can capture footage, the worktable will be lit up.
	Machine a piece of wood	The main purpose of this machine will be to machine a piece of wood to a desired design, this can mean drilling holes, engraving and carving designs.
	Easy to use application	To operate this machine, the user will have access to an easy-to-use program where he/she can easily operate this piece of machinery.

6.1 System Context Diagram(s)

*Rationale: System context diagrams show a system, as a whole and its **inputs** and **outputs** from/to external factors. From technology and user perspective it provides an overview of the context in which the system must operate. And if a system comprises various sub-systems, also provide an overview of each subsystem and how they interact. Further details are explained in the ES course.*

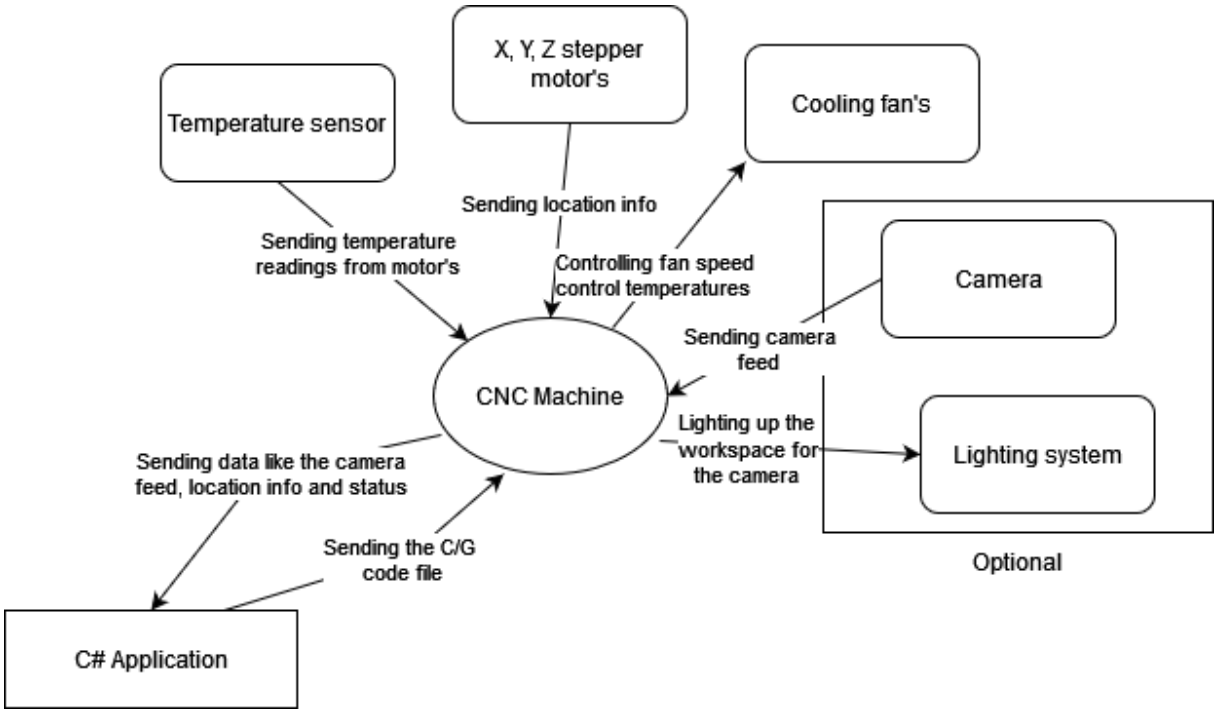


Figure 1

6.2 Problem analysis

Rationale: this section is about understanding the technical challenges your team needs to solve.

Answer questions such as: What is problem is the customer facing? What are the sources and consequences of those problems? You could use techniques such as root-cause analysis here. Tools like five-why's work well.

Our customers' goal is to increase their profits, they want to accomplish this by hiring Plantastic to develop a product that will reach another market and increase their customer base. With this project,

the customer's demands will be accomplished by entering a new market, increasing their customer base and thus increasing their profits.

7 Project requirements

Rationale: this section is about expectation management towards your customer. What can your customer expect from your team and what not.

Describe in global wording what activities belong to the project (in scope), and which are explicitly excluded (out of scope).

7.1 Actors

Rationale: Actors for the basis for defining scope. Any actor included incurs extra functionality to it's important to specify what actors are included.

Write down a list of included actors. Specify which actors excluded in case of doubt.

Type of actor	Actor
Human	User
Software	C# application

7.2 Scenario's

Rationale: Scenario's are the basis for uncovering what functionality the system has to support.

Write down a list of scenario's that describe how the system is used.

Actor	Scenario
User/C# application	The user creates a CAD/CAM file, the user then mounts a piece of wood with the right dimensions on the worktable of the CNC machine, when the piece of wood is mount securely, and the enclosure is closed he turns on the machine. When the machine is turned on, the user uploads his file to the application and clicks on the start button. The tool spins up to speed and starts the machining process.
User	The user started the machining process and noticed the piece of wood is not mounted securely; he presses the emergency stop button. The machine shuts down.
User/C# Application	The user wants to see what is happening inside of the safety enclosure, he clicks on a button inside of the application. The application opens a window where the user can watch the live camera feed.
User	The user had to press the emergency stop button because the piece of wood was not securely mounted on top of the worktable, he has to open the application and restart the application from the beginning.

7.3 Use cases

Rationale: Use cases visualize what functions your system support.

Use your scenario's to uncover which use cases are going to be supported by the system. Only write down the use cases here with a short description. The details are in appendix A.

The use case of the CNC machine will be to give the user the ability to precisely engrave and/or drill the wood as desired in the design. The user will be able to follow the process of the CNC machine through a camera and XYZ coordinates of the tool head. For further details about the the use cases, please refer to 12 Appendix A detailed use cases.

8 Communication protocol

Rationale: When two or more sub-systems must interact, they shall use a communication protocol that is bidirectional and is able to cope with communication errors. Three aspects are important when defining a protocol: Command syntax, list of all available commands, dynamic behavior when sending and handling commands and responses.

Example command: #COMMAND:PARAM1,PARAM2%
Example response: #ACK% or #NACK%

Figure 2: example or command syntax, replace your syntax here

<your text to explain details>

Table 4: example commands overview, replace your command set here

Name	Purpose	Syntax	Response	Details
RESET	*Reset a sub-module to it default settings*	*#RESET%*	*#ACK%*	
MOVE	*Move an axis to a certain position*	*#MOVE:ID,POS%*	*#ACK%* *#NACK%*	*ID: identification of axis to be moved* *POS: target position in [mm]*
MEASURE	*Get the measurement value of a sensor*	*#SENSOR:ID%*	*#ACK,VAL%* *#NACK%*	*ID: identification of sensor* *VAL: measurement value returned to sensor*
<your text>	<your text>	<your text>	<your text>	<your text>

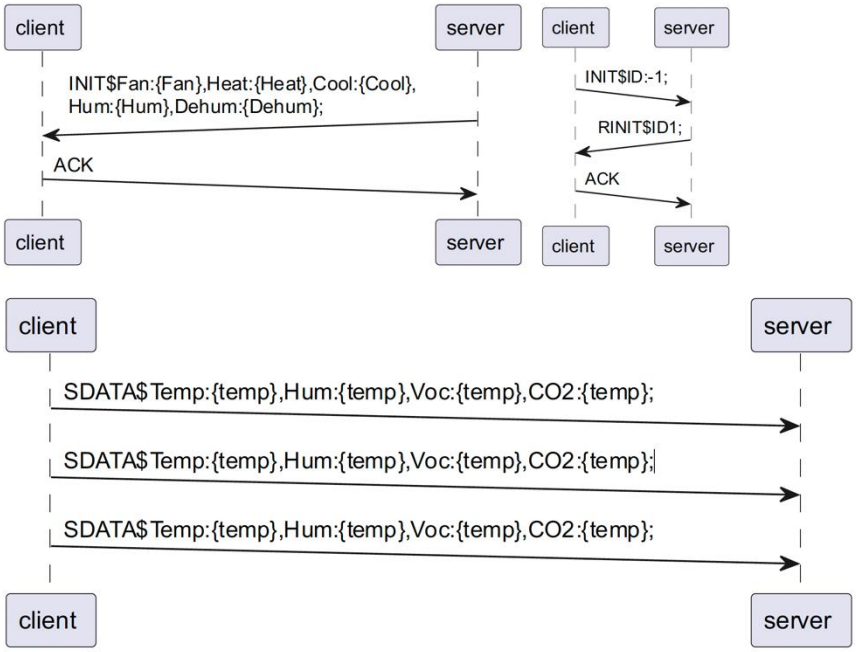


Figure 3: an example of a "sequence" diagram, replace your diagram here

9 Hardware design

Rationale: creating hardware diagrams gives and overview of all components and how they are interconnected. Also add a table to list all pins and IO-types. This indicates whether system is feasible from HW point of view.

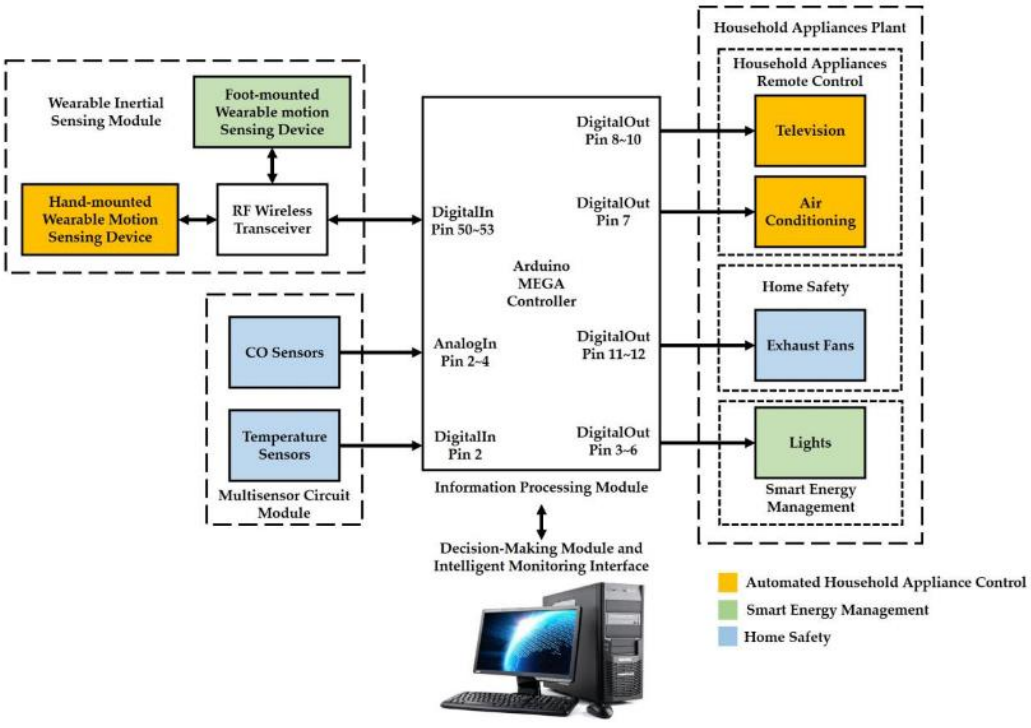


Figure 4: an example of a "system hardware modules" diagram, replace your diagram here

Table 5: an example of a connection table, replace your table here

Sensor/Actuator	Pin protocol	Pin
BME280 (Temperature, Humidity)	(SDA), (SCL) - (I2C)	GPIO 21, 22, GND, 3.3V
Fan	(Analog) - Output (PWM)	GPIO 4, GND, 5V (VIN)
Motion sensor	(Digital) - Input	GPIO 34, GND, 3.3V
3 LED	(PWM)	GPIO 18, 19, 5, GND
LDR (light detecting sensor)	(Analog) - Input	GPIO 36 (VP), GND, 3.3V
Air quality sensor	(SDA), (SCL) - (I2C)	GPIO 21, 22, GND, 3.3V
3 Buttons	(Digital) - Input	GPIO 12, 13, 14, GND, 3.3V
LCD	(SDA), (SCL) - (I2C)	GPIO 21, 22, GND, 5V (VIN)

10 Embedded software Design

Rationale: Proper embedded software design increases the likelihood of a working end-product. Designing flow charts (and state machines if applicable) before creating code is a good engineering practice.

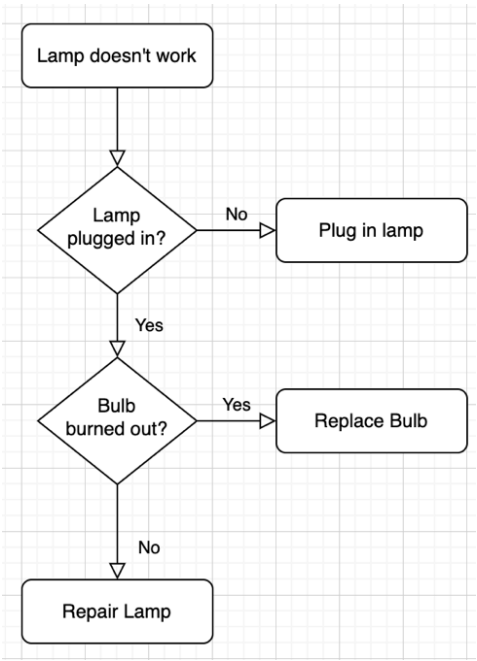


Figure 5: an example of a flow-diagram, replace your own diagram here

<your text to explain details about the flow of your embedded software>

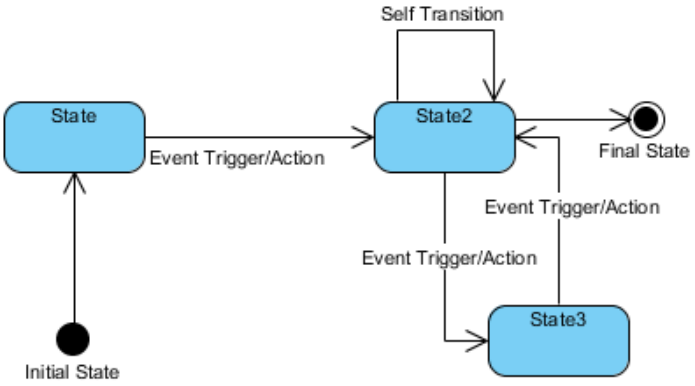


Figure 6: an example of a "state machine" diagram, replace your own diagram here

<your text to explain details about state machine behavior of your embedded software, if applicable>

11 PC software Design

Rationale: Proper PC software design increases the likelihood of a working end-product. Designing GUI designs and software class diagrams before creating code is a good engineering practice.

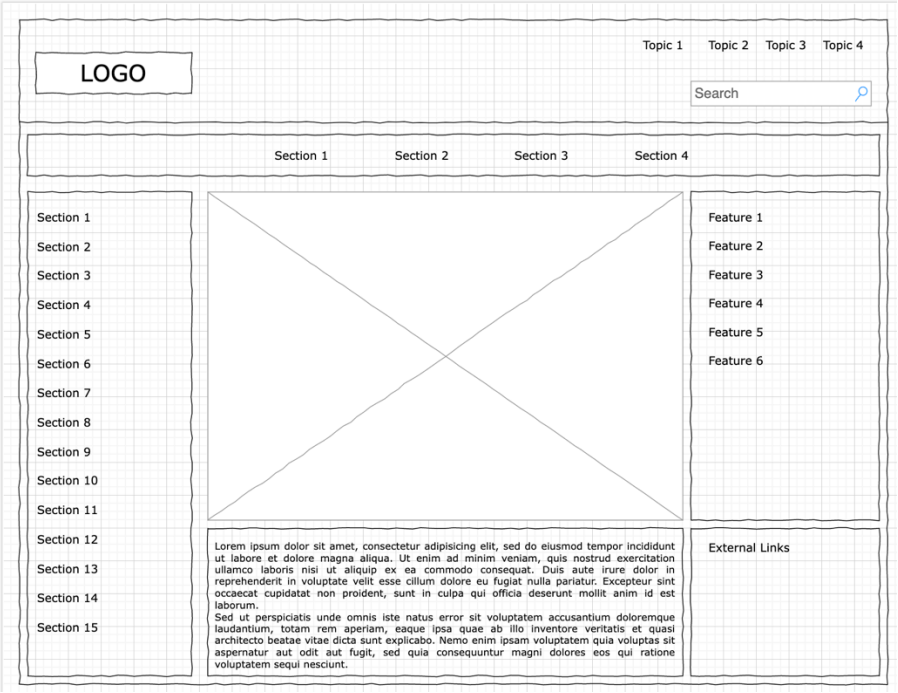


Figure 7: an example of a wire frame diagram, replace your own diagram here

<your text to explain details about the GUI>

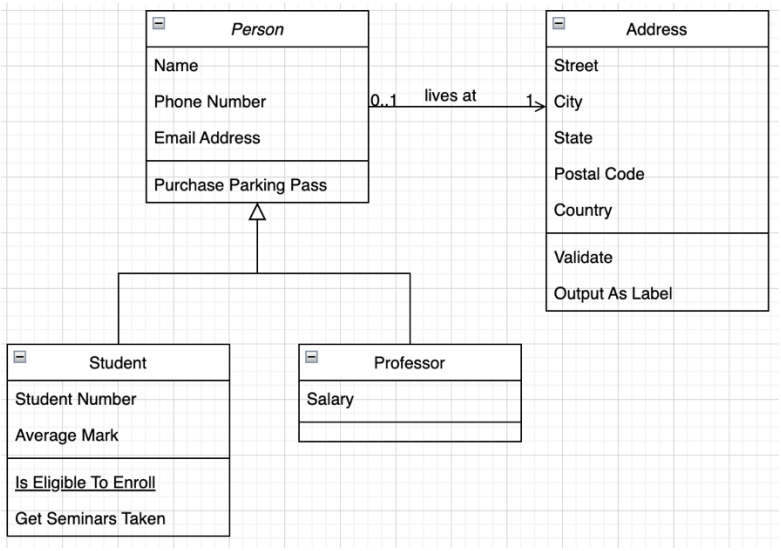
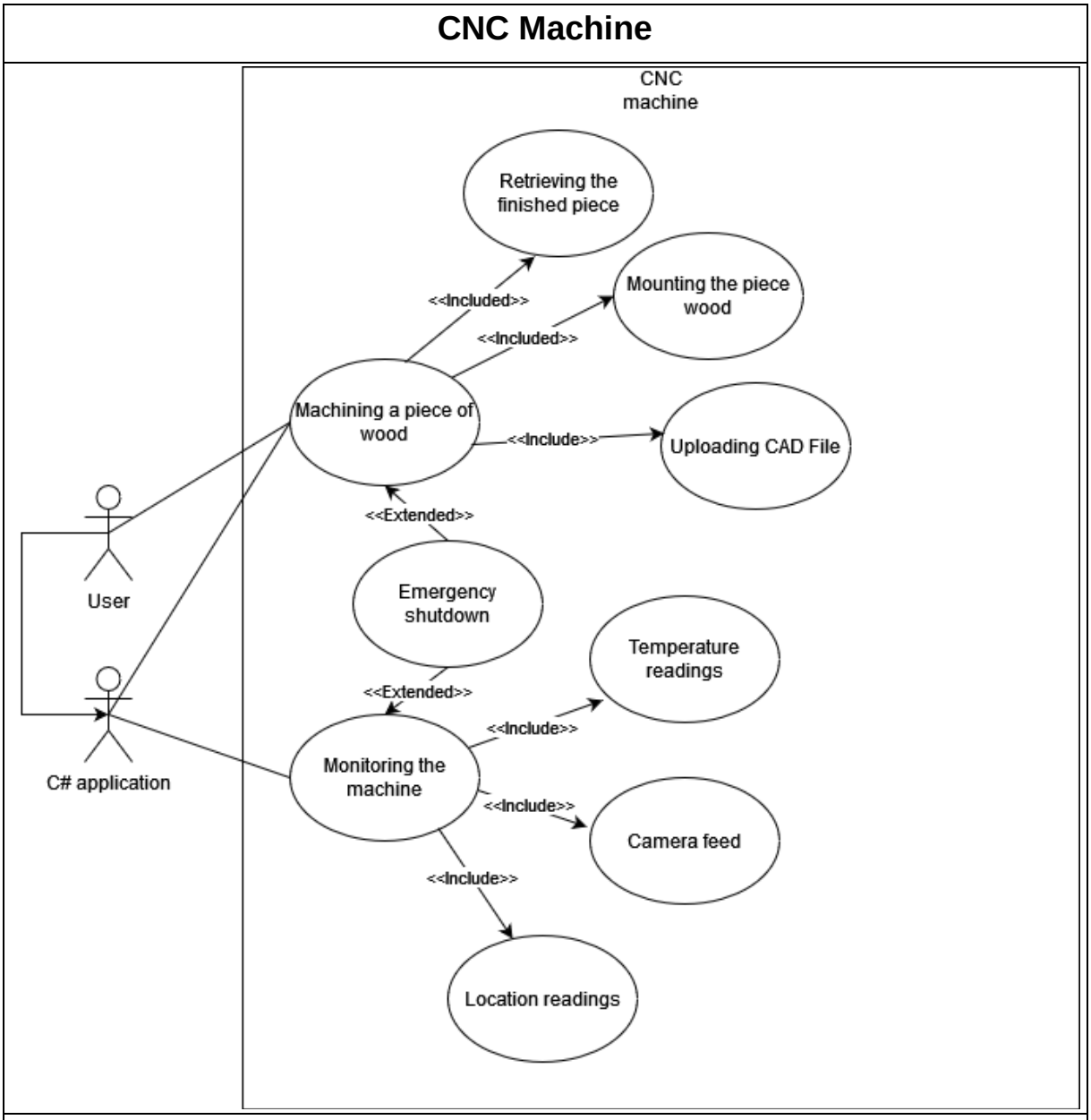


Figure 8: an example of a class diagram, replace your own diagram here

<your text to explain details about the PC software design>

12 Appendix A detailed use cases



Use case name	**CNC Machine**
Use case number	**1**
System	**CNC Machine**
Actors	1.User 2. C# Application
Use case goal	**Operation of the CNC Machine and step**

	required to do so.
Primary actor	**User**
Preconditions	1. Necessary materials 2. Knowledge on how to operate the machine
Basic flow	**1. The user creates a CAD file of the required design.** **2. The user get the material in the correct dimensions for the CNC machine.** **3. The user mounts the required material with the correct dimensions securely into the machine.** **4. The user uploads a CAD file of the required design to the CNC machine.** **5. The user activates the CNC machine.** **6. The user monitors the CNC machine.** **7. Once the machine is finished, the user can retrieve the material from the machine.**
Alternative flows	1-2. The user could get the material in the correct dimensions for the CNC machine and could create the CAD file of the design in the reverse order. 3-4. The user could upload a CAD file of the required design to the CNC machine and could mount the required material with the correct dimensions securely into the machine in a reversed order.
Exceptional flows	1. If the required material of the CNC machine was incorrectly inserted. The machine could be stopped with an emergency button that shuts down the entire machine.
	2. If the machine was operated incorrectly and someone could be/is in harm's way, the machine could be stopped with an emergency button that shuts down the entire machine.

13 Appendix: relevant tools

Table 6: Tools to create various diagrams

Purpose	URL
Create UML diagram	Online UML diagram tool | Lucidchart
PlantUML	Open-source tool that uses simple textual descriptions to draw beautiful UML diagrams. (plantuml.com)

Various diagrams and charts	Diagram Software and Flowchart Maker