Requirements Documentation

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CS2013: Outline for a Requirements Document

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1. Introduction

1.1. Overview – Purpose of system

The purpose of this group project for CS2013/CS3013 is to design and create machine learning models for tracking gross-motor skills for our client in the SCSS department. Our client is doing research on the development of gross-motor skills in young children and has asked that we create a machine learning model to help track certain movements to be able to determine whether the children can perform the motor-skills, and hence the overall purpose of our project is to create machine learning models that can recognize such motor-skills.

This project will help our client spend more time collecting data for his research rather than spending time developing the machine learning aspects himself.

1.2. Scope

The scope of this project consists of developing an efficient and accurate machine learning model that can identify what movement is being performed when a json file containing motion capture data is passed through the model.

The machine learning model will be presented with a motion capture data file and will determine which motor-skill it is relating to. It will look to determine how many times the skill was performed for each motion capture data file. In order for a motion to be considered 'successful' the machine learning model determines if it was performed sufficiently, i.e. if the motor-skill being checked for is a hop and the child jumped off one foot but landed on two, this is not considered a successful iteration of the motor-skill.

1.3. Objectives and success criteria

Our objective is to fully deliver the items described in the scope as well as any additional time permitting functions. Our success criteria include a fully functional and tested machine learning model that can be integrated and used on the clients existing system to compare the results he has previously gotten. Our main objective is to produce something useful for the client that actually works and will benefit his research within the given time-frame.

Our client has data collected for six different motions, However due to the limited time frame they have acknowledged that making six machine learning models may be quite a feat. To ensure that we successfully deliver a system of high quality, we have been guided to focus primarily on 3 of the motions: jog, hop left and hop right. Once we have completed these models to a high and accurate standard, we may then have time to train additional models.

Our main objective is to deliver to our client machine learning models that process these three motor-skills. We want our system to be accurate and extensible, that is that we want our client to be able to easily train the model with new data as well as getting consistent and accurate results on test data.

1.4. Definitions, abbreviations

Deep learning

Deep learning is an artificial intelligence function that imitates the workings of the human brain in processing data and creating patterns for use in decision making. Deep learning is a subset of machine learning in artificial intelligence (AI) that has networks capable of learning unsupervised from data that is unstructured or unlabeled. Also known as deep neural learning or deep neural network.

Gross-Motor Skills

Gross motor (physical) skills are those which require whole body movement and which involve the large (core stabilising) muscles of the body to perform everyday functions, such as standing and walking, running and jumping, and sitting upright at the table.

Machine learning

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it to learn for themselves.

The process of learning begins with observations or data, such as examples, direct experience, or instruction, in order to look for patterns in data and make better decisions in the future based on the examples that we provide. The primary aim is to allow the computers learn automatically without human intervention or assistance and adjust actions accordingly

Neural networks

Neural networks are a set of algorithms, modeled loosely after the human brain, that are designed to recognize patterns. They interpret sensory data through a kind of machine perception, labeling or clustering raw input. The patterns they recognize are numerical, contained in vectors, into which all real-world data, be it images, sound, text or time series, must be translated.

1.5. References

Deep Learning

https://www.investopedia.com/terms/d/deep-learning.asp

Gross-motor Skills

https://childdevelopment.com.au/areas-of-concern/gross-motor-skills/

Machine Learning

https://expertsystem.com/machine-learning-definition/

Neural Networks

https://pathmind.com/wiki/neural-network

2. Current system

Our client’s current system is focused primarily on recording motion capture data. The system's intended use is to record movement patterns on motor skills. The client is using a Microsoft XBOX Kinect to collect infrared motion capture data to track each individual joint of a test subject while they move. Each joint’s XYZ coordinate positional tracking data is compiled into a set of joints,or a ‘skeleton’.

The existing system being used in our client-s research to collect raw positional and rotational tracking data (3D position of each joint of the body over a period of time) from 40 test subjects who each performed a number of different tracked motions, e.g. hop on left and right foot, jumping side to side, jumping with both feet, and jumping forward.

There are no machine learning models that work concurrently with the system; producing these models are our tasks for this project. Using the motion capture data acquired from the current system, we will train our machine learning models to recognize each individual motion.

Before our involvement in this project, our client had developed a non-machine learning algorithm for analysing the data that has been gathered. To test our machine learning models to their fullest extent, we will compare the accuracy of our models to that of the results of our clients current system as we near the finalized models.

3. Proposed System

3.1. Overview

Our machine learning model will implement both a frontend and a backend which will allow for ease of use by the client. The frontend will implement a simple file selection system, which will allow the client to assign .json files to be read by the machine learning model. The backend will take in files selected in the selection system and parse the .json files into a readable data format. The system will have a pre-baked machine learning model that predicts motions at approximately 90% to 95% accuracy. After the .json files have been parsed, they will be sent into the pre-baked model, and will output a list of the motions that have been inputted to the frontend, followed by which motion they are most likely to represent. These results will then be displayed to a frontend panel, which will be capable of exporting the result into a variety of file formats (e.g. .XLS, .CSV, .XML, .JSON, etc.)

3.2. Functional Requirements

*A **Functional Requirement** (FR) is a description of the service that the software must offer. It describes a software system or its component. A function is nothing but inputs to the software system, its behavior, and outputs. It can be a calculation, data manipulation, business process, user interaction, or any other specific functionality which defines what function a system is likely to perform.https://www.guru99.com/functional-requirement-specification-example.html*

- The system will be able to process .json motion capture files uploaded by the user.
- The system will parse the files for the machine learning model to process.
- The machine learning model will be able to read the data parsed from the .json file and output the most likely motion that the file represents.
- The system will be able to accurately predict the iterations of each motion from the .json motion capture file (e.g. if the motion is determined to be a Hop-Left, the system will be able to predict how many times a Hop-Left was done in the motion capture.).
- The system should store the results in a file document.
- The machine learning model should have an accuracy of at least 80%.

3.3. Non-functional Requirements

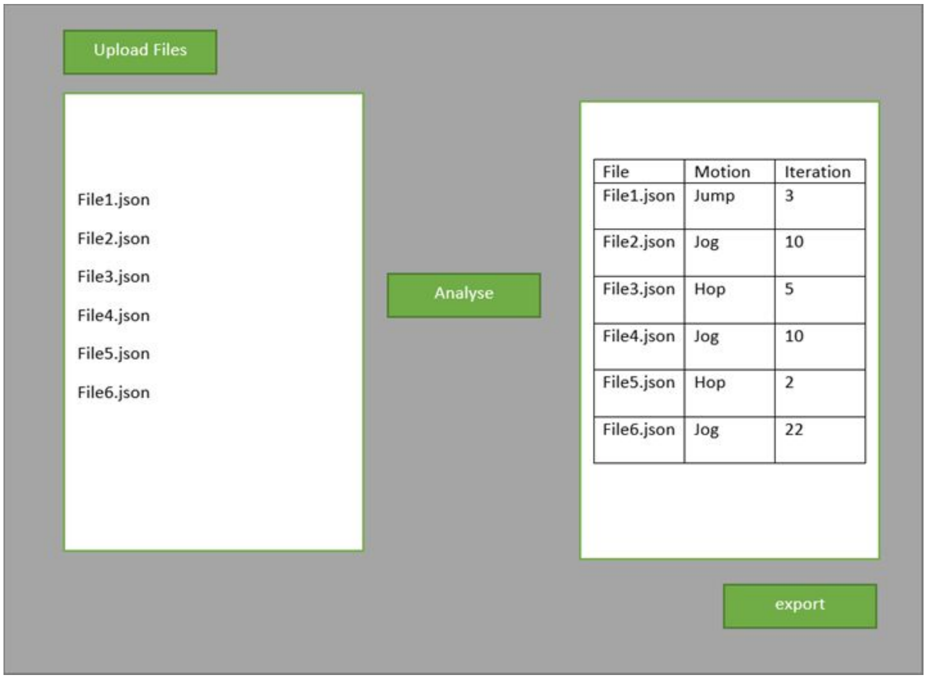
*A **Non-Functional Requirement** (NFR) defines the quality attribute of a software system. They judge the software system based on Responsiveness, Usability, Security, Portability and other non-functional standards that are critical to success of the software system. Example of nonfunctional requirement, how fast does the website load? Failing to meet non-functional requirements can result in systems that fail to satisfy user needs.https://www.guru99.com/non-functional-requirement-type-example.html*

- The frontend will be able to load multiple motion capture files at once to be read by the machine learning model and be able to output multiple results.
- The front end GUI will be user friendly and easy to navigate.
- The frontend will be able to export results of the processed data into one of several file formats.
- The model should be able to be refined (e.g. swapped for a more refined model) using a series of supervised machine learning techniques.

3.4. System prototype (models)

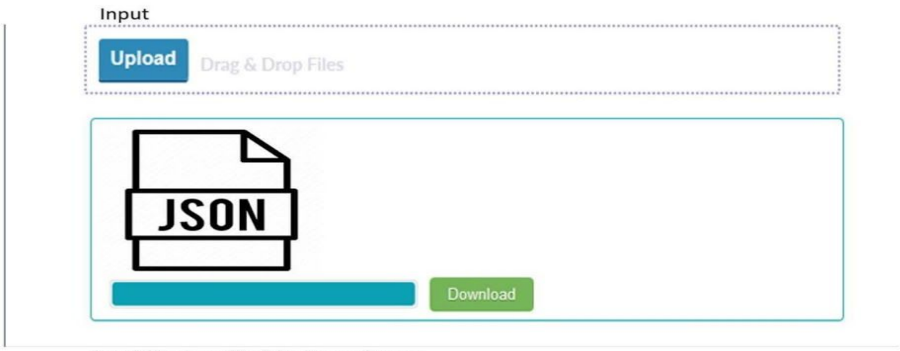
3.4.1. User interface mockups

In our mockup phase, we have produced two different potential user interface designe which would allow the client to easily use the system. A well designed GUI is important for this task; our client should be able to easily access and send the data to the system without much hassle. Our first is a simple table-to-table GUI. The user would simply append the files into the first window, click ‘analyze’, await analysis, and be able to view the results in tabulated form within minutes.



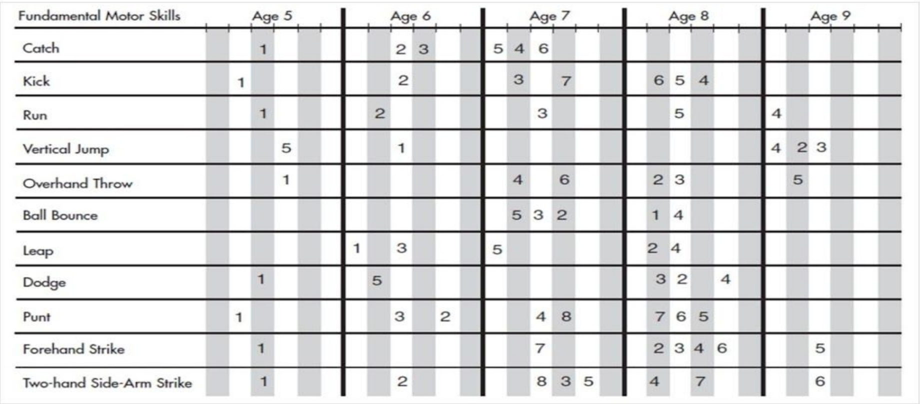
File	Motion	Iteration
File1.json	Jump	3
File2.json	Jog	10
File3.json	Hop	5
File4.json	Jog	10
File5.json	Hop	2
File6.json	Jog	22

Json file input



Input the json file into the software

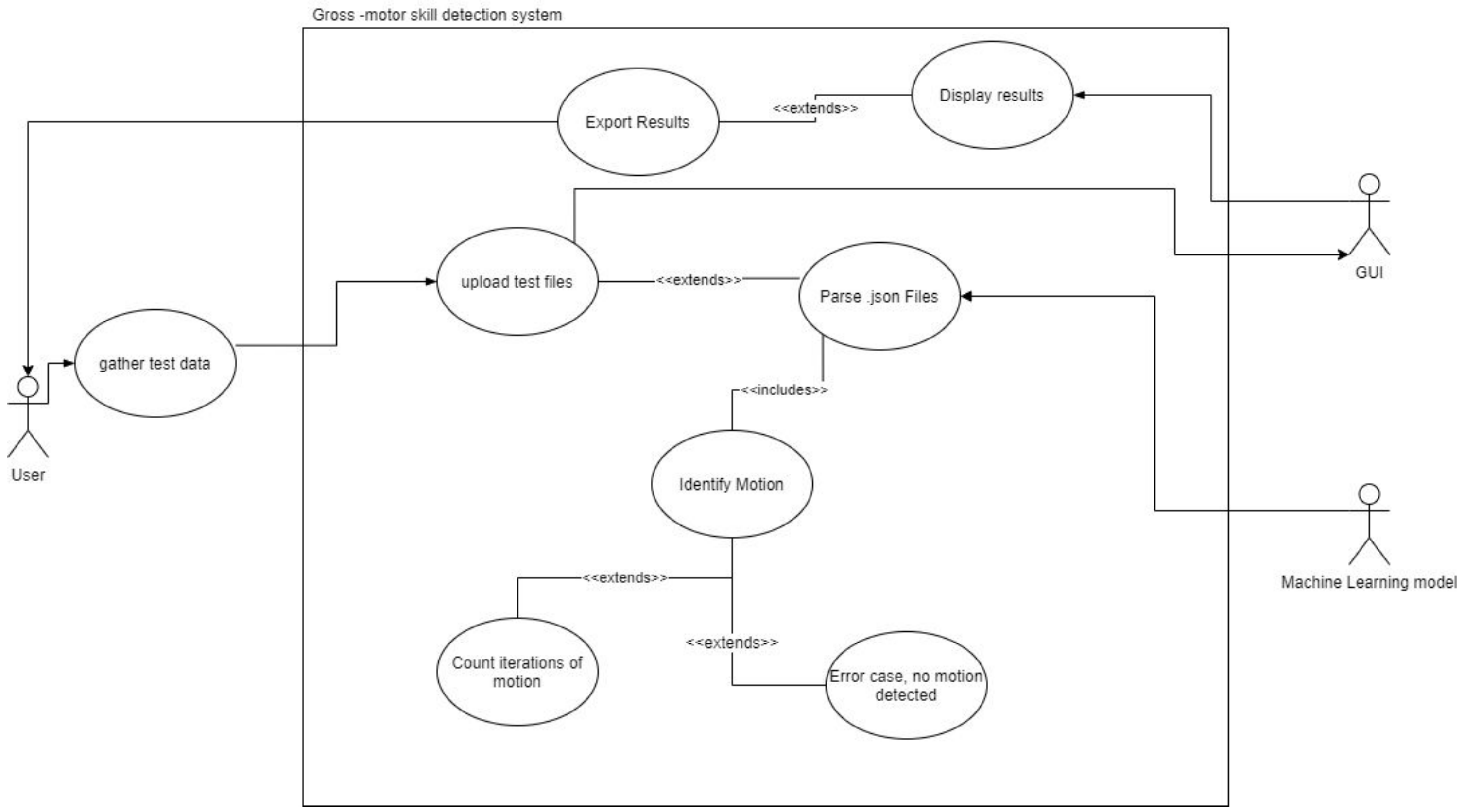
Output the result table:



Fundamental Motor Skills	Age 5	Age 6	Age 7	Age 8	Age 9
Catch	1	2 3	5 4 6		
Kick	1	2	3 7	6 5 4	
Run	1	2	3	5	4
Vertical Jump	5	1			4 2 3
Overhand Throw	1		4 6	2 3	5
Ball Bounce			5 3 2	1 4	
Leap		1 3	5	2 4	
Dodge	1	5		3 2 4	
Punt	1	3 2	4 8	7 6 5	
Forehand Strike	1		7	2 3 4 6	5
Two-hand Side-Arm Strike	1	2	8 3 5	4 7	6

3.4.2. Use cases (including text narratives)

Use Case Diagram



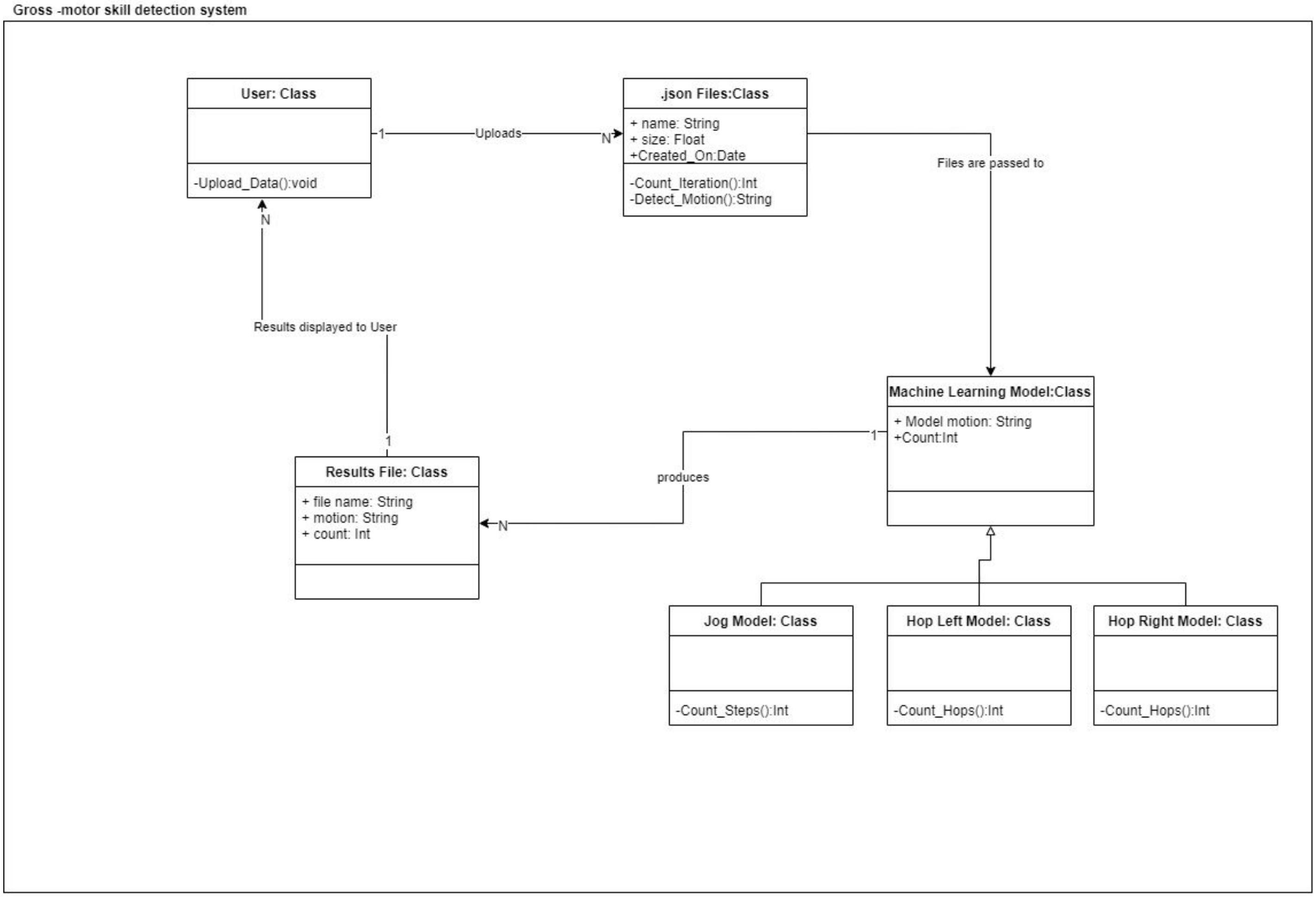
Textual Descriptions

Name: Upload test files Participating actors: User, GUI Entry condition: the user has test files to upload Exit condition: the files are uploaded to the GUI Normal scenario: the user uploads the files they want to process Error scenario: the user tries to upload non json files, told the file type is incompatible.	**Name: Gather Test Data(outside system)** Participating actors: User Entry condition: User has test subject and access to kinect. Exit condition: Data on coordinates frames is collected as a json Normal scenario: The test subjects movements are captured and mapped by the kinect and stored as a json file of coordinate frames Error scenario: The test subjects movements could not be mapped or recorded

Name: Parse .JSON Files Participating actors: Machine Learning Models Entry condition: files are uploaded via the GUI Exit condition: The data is parsed into a processable format Normal scenario: The files uploaded are parsed to be passed to machine learning model Error scenario: the files are unable to be parsed	**Name: Export Result** Participating actors: GUI, User Entry condition: The files were successfully processed and results were produced Exit condition: The user has an exported copy of the results Normal scenario: The user clicks "export" and the results are exported as a file Error scenario: The export fails, user told to retry
Name: Identify Motion Participating actors: Machine Learning Models Entry condition: Files have been parsed and user clicks 'analyse' Exit condition: The machine learning model identifies the motion in each file Normal scenario: The user clicks the 'analyse' and the testing data is passed to the learning model to identify each files motion Error scenario: motion could not be identified	**Name: Display Result** Participating actors: GUI Entry condition: The files were successfully processed and results were produced Exit condition: The outcome displayed on the screen and written into a file Normal scenario: The machine learning model produced results in a file and are displayed to the User on the GUI Error scenario: The machine learning model could not produce results.
Name: Count iterations of motion Participating actors: machine learning model Entry condition: the motion has been identified Exit condition: the number of times the motion was completed in each files is recorded Normal scenario: the model counts how many times in each file, the relevant motion is fully completed Error scenario: The model is unable to detect if the motion is not being performed properly	

3.4.3. Object model

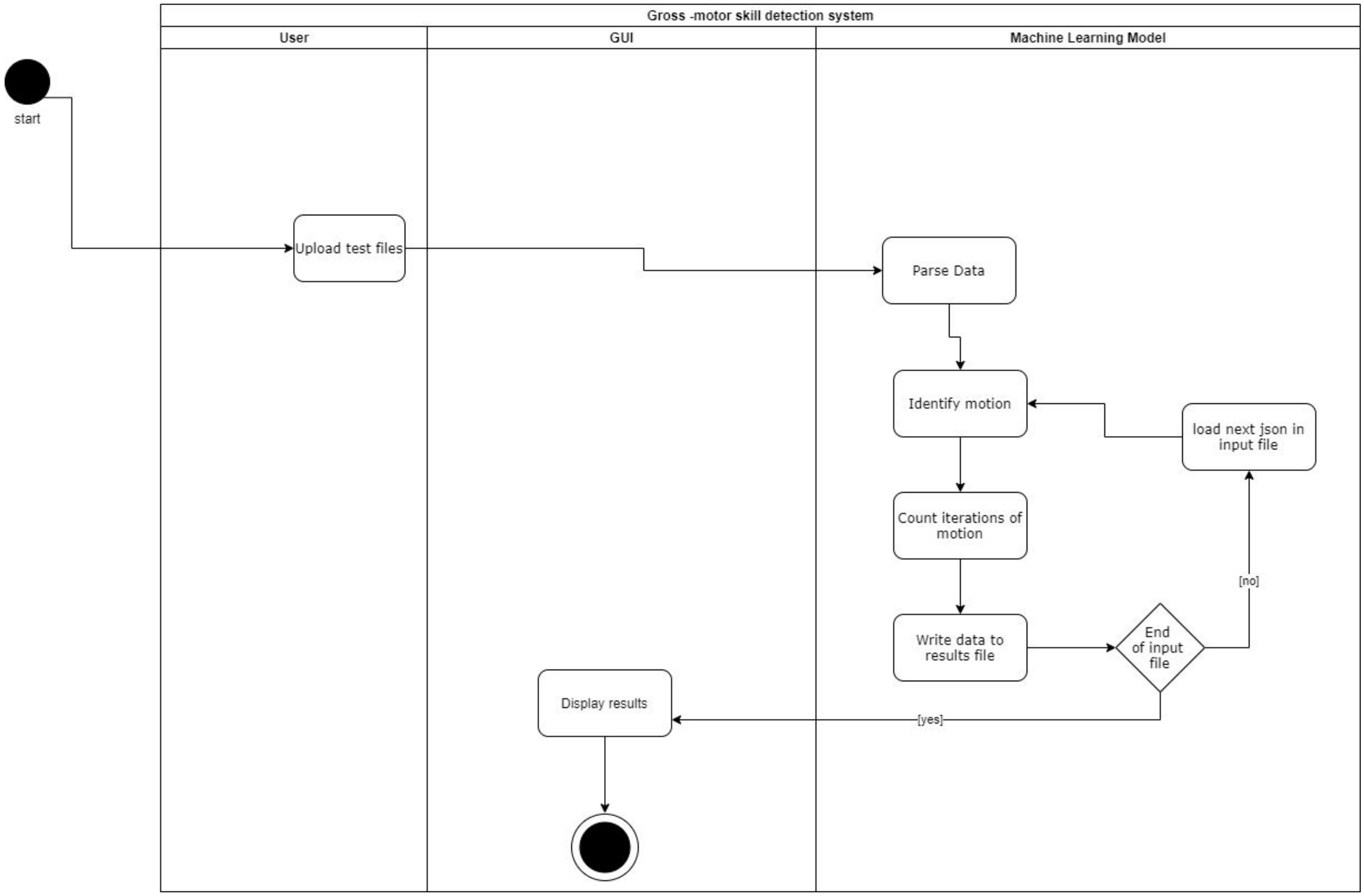
Class Diagram



The class diagram above shows how we expect the elements of our system to interact

- The user uploads multiple .json files
- These files are then passed to the machine learning model
- There are 3 machine learning models; jog, hop left and hop right (indicated by inheritance)
- The machine learning model then produces multiple results files
- The results are then displayed to the user

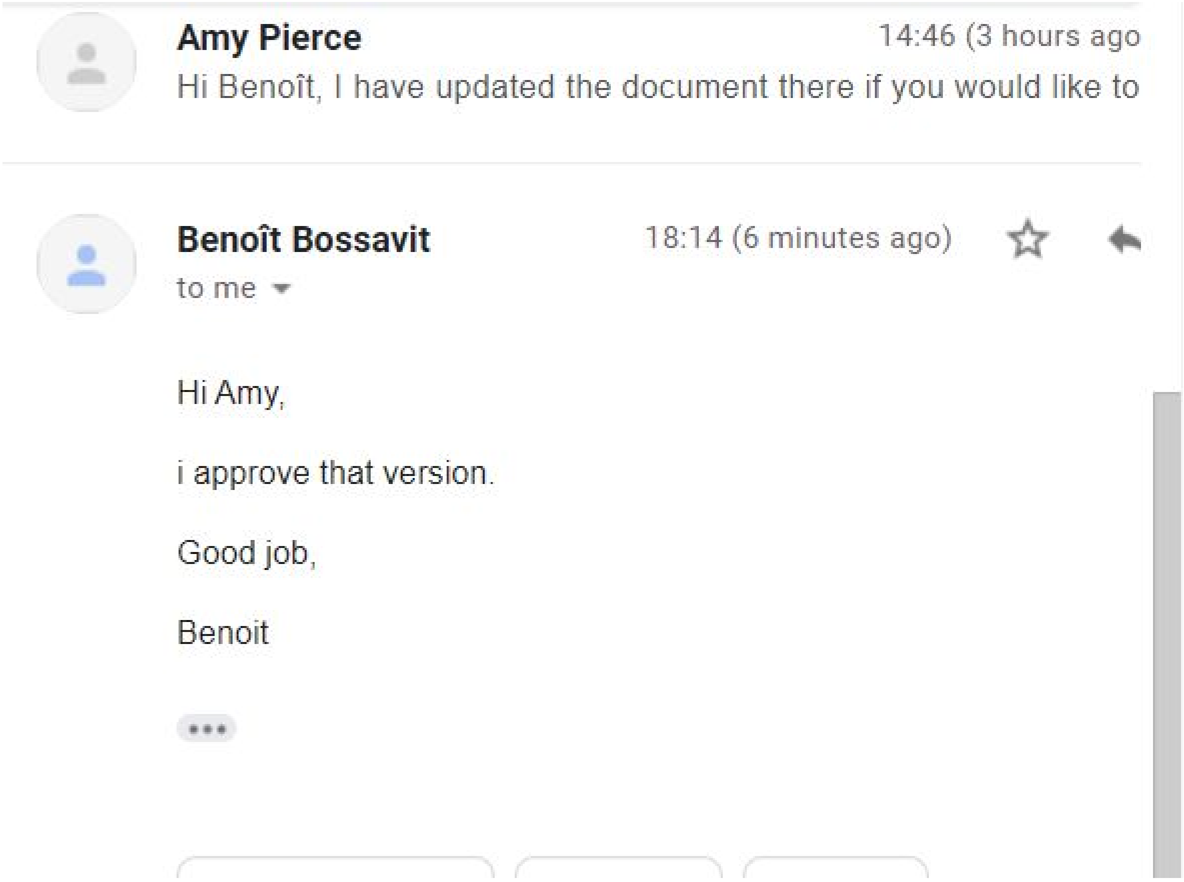
3.4.4. Dynamic model



Our Dynamic model (Activity diagram) shows the happy case order of events for our system, i.e. it ignores error cases such as the user uploading incorrect data or the machine learning model crashing.

- A user uploads research data which is then parsed.
- The first file in the data set is processed to identify the movement and see how many complete movements were recorded.
- If there are no more files in the data set, the process is over. Otherwise, the system moves to the next file and repeats until all files have been processed.
- When the end of the file is reached, the results are displayed.

4.Client Sign-Off



Amy Pierce 14:46 (3 hours ago

Hi Benoît, I have updated the document there if you would like to

Benoît Bossavit 18:14 (6 minutes ago)

to me

Hi Amy,

i approve that version.

Good job,

Benoit