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Home

Project Overview: ChatGPT and NAO Robot

Image source: github.com/CHRI-Lab/cowriter_letter_learning

Composed of a set of ROS nodes that facilitate the user interaction with a robot, the CoWriter project is designed for children to teach a social robot handwriting. The intuition behind this interaction is "learning by teaching" where children can have the acquisiton of handwriting by teaching a robot to write better. Na o is an autonomous, programmable humanoid robot and has been used for demonstration purposes for this project. Last semester, three different teams from the Software Project subject (COMP90082) took over this project with goals to 1) update the CoWriter project from Python2 to Python3 and 2) integrate ChatGPT to enable NAO robot to have conversations with children. Currently, these projects are each deployed in different environments and have achieved slightly different outcomes.

This project aims to:

1. merge the previous projects in one unified environment;
2. update UI;
3. improve the interaction between children and robot;
4. persoanlise learning expereince.

Team NA-Redback

Name (Preferred Name)	Role	Contact	Bio
Wafa Johal	Client	wafa.johal@unimelb.edu.au	Dr Wafa Johal is a senior lecturer at the School of Computing & Information Systems, Faculty of Engineering and Information Technology, University of Melbourne. Her research focuses on human-robot/computer interaction and intelligent and autonomous systems.
Sebastian Bobadilla	Supervisor	bobadillacha@unimelb.edu.au	Sebastian is part of the teaching team for COMP90082 Software Project subject and is a supervisor for the NA-Redback team who oversees the progress of this project.
Eunji Kim (Rachel)	Product Owner, Dev Member	kimek@student.unimelb.edu.au	Rachel is a final-year master's student in IT specialising in AI at the University of Melbourne. Her interests lie in data analytics, natural language processing, and human-computer interaction.

Recent space activity

Aurelien Plaire
Presentation Slides updated about 5 hours ago view change

Chien-Pu Lin
| Sprint Retrospective updated about 5 hours ago view change

Aurelien Plaire
Sprint 4 Review updated about 5 hours ago view change
| Sprint Retrospective updated about 5 hours ago view change

Difan Wu
Product Video updated about 5 hours ago view change

Space contributors

- Aurelien Plaire (4 hours ago)
- Chien-Pu Lin (4 hours ago)
- Difan Wu (5 hours ago)
- EUNJI KIM (6 hours ago)
- Yangchen Shen (2 days ago)
- ...

Difan Wu	Scrum Master, Dev Member	difanw@student.unimelb.edu.au	Difan Wu is a Master of IT - Artificial Intelligence student at the University of Melbourne. Originally trained as an architect, his innate curiosity, determination and adaptability led him to embrace a new challenge in the world of IT. Currently, he is focusing on large data processing, machine learning and computer vision.
Aurelien Plaire	Tech Lead	aplaire@student.unimelb.edu.au	Aurélien is a former general engineering student at CentraleSupélec, completing a double degree at the University of Melbourne (Master of IT - Computing). His interests lie in data processing and management, and software development.
Chien-Pu Lin (Jeff)	Test Lead	chienpu.lin@student.unimelb.edu.au	Jeff is a Master of IT student, specializing in AI, at the University of Melbourne. His interests spanning AI, machine learning, cloud computing and robotics. He is eager to dive into cutting-edge technologies and innovations.
Yangchen Shen (Shen)	Quality Lead	yangchens2@student.unimelb.edu.au	Shen is a Master of IT student at the University of Melbourne. His interests lie in natural language processing, data processing and management, and software development.

Links to our Project

- **Trello board**
- **Github repository**

| Project Introduction

Overview

> *Image source: https://github.com/CHRI-Lab/cowriter_letter_learning*

Composed of a set of ROS nodes that facilitate the user interaction with a robot, the **CoWriter project** is designed for children to teach a social robot handwriting. The intuition behind this interaction is "learning by teaching" where children can have the acquisiton of handwriting by teaching a robot to write better. When words are requested by displaying cards to the robot with chilitags on them, children then correct the robot's simulated handwriting by demonstrating on a tablet. This demonstration is subsequently used to improve the robot's shape learning algorithm. NAO is an autonomous, programmable humanoid robot and has been used for demonstration purposes for this project.

Last semester, three different teams from the Software Project subject (COMP90082) took over this project with goals to 1) update the CoWriter project from Python2 to Python3 and 2) integrate ChatGPT to enable NAO robot to have conversations with children. Currently, these projects are each deployed in different environments and have achieved slightly different outcomes.

References for the previous projects including code and documents can be found in the links below (please email the dev team for access):

- NAOHW-RedBack
- NAOHW-BlueRing
- NAOHW-Boxjelly

Project Summary

This project, "ChatGPT and NAO Robot (Code: NA)", aims to:

1. merge the previous projects in one unified environment;
2. update UI;
3. improve the interaction between children and robot;
4. persoanlise learning expereince.

Client Goals

Our client is **Dr Wafa Johal**, who is a senior lecturer at the School of Computing & Information Systems, Faculty of Engineering and Information Technology, University of Melbourne. Her research focuses on human-robot/computer interaction and intelligent and autonomous systems. Through the CoWriter Project, she aims to examine the application of the learning by teaching on motivating children to practice their handwriting skills accompanied with a humanoid robot (NAO).

The client goals can be largely divided into four:

1. Integration of previous projects in a single repository
2. Improvement of the CoWriter software
    - Optimise the learning process by being able to identify letters the children is struggling with
    - Generate personalised words in line with child's interest
    - Update UI:
        - Make the UI more user-friendly by integrating kids-friendly illustrations
        - Move to a web version (browser) from PyQT
        - Investigate possibility to have a cross platform UI such as iOS – apple pencil and Wacom (Out-of-scope)
3. Refinement of conversation using ChatGPT
    - Ensure that the conversation stays child-friendly
    - Enhance the interaction by incorporating motions/gestures to NAO robot during conversation (using the existing motion library)
    - Generate the code for new motion based on the text (Out-of-scope)
4. Upgrade ROSbag data management
    - Implement logging and annotation module

Scope

In Scope

- Integration of previous projects in a single repository
- Optimise the learning process by being able to identify letters the children is struggling with
- Generate personalised words in line with child's interest
- Update the CoWriter UI by
    - moving to a web version (browser)
    - adding generated illustration
- Use ChatGPT to
    - maintain child-friendly and safe conversation between a robot and children
    - elicit motions/gestures to NAO robot during conversation (using the existing motion library)
    - Generate personalised words in line with child's interest

Out of Scope

- Investigate possibility to have a cross platform UI such as iOS – apple pencil and Wacom
- Use GPT to generate the code for new motion based on the text
- Implement logging and annotation module

Stakeholders

Role	Internal/External	Engagement	Interests
Client	Internal	High	High
Development Team	Internal	High	High
Children	External	High	Medium
Researchers	External	Medium	Medium
Parents	External	Low	High

Persona

Persona	Titles	Personality	Goals
Alex	Child	• Introvert • Creative • Fickle • Curious	• Fun and Play • Exploration • Positive Reinforcement
Lily	Child	• Extrovert • Analytical • Fickle • Passive	• Variety and Flexibility • Positive Reinforcement • Independence
Emily	Parent	• Introvert • Thinking • Intuition • Perceiving	• Convenience • Engaging Activities • Quality Education • Technology Integration
Olivia	Researcher	• Extrovert • Creative • Loyal • Active	• Cutting-Edge Tools • Effective Learning Solutions • Data-Driver Insights
Alan	Researcher	• Extrovert • Creative • Easy • Active	• Real-World Application • Adaptive Learning • Data-Driven Insight

Alex

"Explore, Play, and Write Your Way to Success with Our Robot Learning Companion!"

Age: 6
Work: Student
Family: Father and Mother
Location: Perth
Character: Active

Organized | Practical | Protective | Hardworking

Bio

Alex is a 6-year-old boy with a curious and energetic personality. He is currently in kindergarten and is at the stage of learning to write his letters. Alex loves to explore the world around him and is fascinated by all things that move, make noise, and light up. He enjoys spending time with his friends, playing games, and drawing.

Personality

Introvert — Extrovert
Analytical — Creative
Loyal — Fickle
Passive — Active

Preferred Channels

Chrome
Mobile
Ins
Facebook

Goals

- **Fun and Play:** Alex values activities that are fun, interactive, and capture his imagination.
- **Exploration:** He is naturally curious and loves to try new things, especially if they involve hands-on experiences.
- ***Positive Reinforcement:*** He thrives on positive feedback and encouragement, which motivates him to keep trying and learning.

Needs & Pain Points

- **Engaging Learning:** Alex is looking for ways to learn that feel like play, where he can have fun while acquiring new skills.
- **Visual and Interactive:** He is drawn to activities that are visually appealing and involve interactive elements like touchscreens or buttons.
- **Encouragement:** He benefits from tools that provide positive reinforcement and celebrate his achievements.

Lily

Age: 8
Work: Student
Family: Parent
Location: Seattle, WA

Bio

Lily is a 8-year-old girl. She has a vibrant and imaginative personality and enjoys spending time exploring creative activities and hobbies. Lily is known for her artistic talents and has a natural ability to come up with unique and imaginative ideas. However, when it comes to traditional studies and academic subjects, Lily often finds it challenging to focus and maintain her interest.

Motivation

Interesting
Complex
Challenging
Helpful
Convenient

Goals

- **Variety and Flexibility:** She thrives in environments that offer a range of activities and opportunities to explore her interests, avoiding monotony.
- **Positive Reinforcement:** She responds well to encouragement and positive feedback, as it boosts her confidence and motivation.
- **Independence:** Lily takes pride in her unique perspective and enjoys working on projects where she can express herself freely.

Personality

Introvert — Extrovert
Analytical — Creative
Loyal — Fickle
Passive — Active

Naughty | Unlearning | Independence

Pain Points & Challenge

- **Lack of Focus:** Lily often struggles to concentrate on one task for an extended period, leading to difficulty in completing assignments or studying for tests.
- **Traditional Study Methods:** She becomes easily bored with traditional study methods that involve reading textbooks or memorizing information.
- **Frustration with Routine:** Lily finds it frustrating to stick to rigid schedules or routines, as they can dampen her creative spirit and sense of exploration.
- **Perceived Failure:** Lily's low tolerance for activities that she doesn't enjoy can lead to feelings of failure or inadequacy when it comes to academics.

Unlock Your Creative Power: Learning Made Engaging, Personal, and Fun!"

Emily

"Empowering my children's learning journey through interactive and personalized experiences is the key to unlocking their full potential."

Name: **Emily**
Gender: **Female**
Age: **35**
Work: **Marketing Manager**
Family: **Married, kids**
Location: **MEL, VIC**
Income: **5000AUD per month**

Busy | Patient | High hopes for her child

Bio

Emily is a 35-year-old parent of two children, aged 5 and 7. She works as a marketing manager for a tech company and is passionate about providing her children with the best learning experiences. Emily is dedicated to finding innovative and engaging ways to support her children's education and development.

Needs & Pain points

- **Educational Support:** Emily is looking for effective ways to help her children learn essential skills, such as writing letters, outside of the traditional classroom environment.
- **Engagement**: She wants her children to be excited about learning and is seeking activities that can capture their attention and maintain their interest.
- **Customization:** Emily recognizes that each of her children has unique learning styles and needs, so she values tools that can adapt and provide personalized experiences.
- **Transitioning from Play to Learning:** Emily faces the challenge of seamlessly transitioning her children from playtime to focused learning activities, and she seeks tools that can make this transition engaging and enjoyable for her kids.

Goals

- **Convenience:** Emily's busy work schedule makes it important for her to find efficient and convenient ways to support her children's learning outside of school.
- **Engaging Activities:** She values activities that are not only educational but also enjoyable and interactive for her kids.
- **Quality Education:** Emily believes in the importance of a strong educational foundation for her children and actively seeks out tools and resources to enhance their learning.
- **Technology Integration:** As someone working in the tech industry, Emily is comfortable with technology and appreciates its potential to enhance her children's learning experiences.

Personality

Introvert — Extrovert
Thinking — Feeling
Sensing — Intuition
Judging — Perceiving

Dr Olivia Bennett

Age: 50
Work: Researcher
Family: Single
Location: San Jose, CA
Character: The Computer Nerd

Friendly | Clever | Go-Getter

Goals

- **Educational Excellence:** Dr. Bennett is deeply committed to advancing the field of education and ensuring that all children have access to high-quality learning experiences.
- **Evidence-Based Practices:** She believes in the importance of using research and data to inform educational strategies and create effective learning environments.
- **Holistic Learning:** Dr. Bennett values a holistic approach to education, emphasizing not only academic skills but also social, emotional, and cognitive development.

Needs and Challenges

- **Cutting-Edge Tools:** Dr. Bennett is always on the lookout for innovative tools and technologies that can enhance teaching and learning, aligning with her research-oriented mindset.
- **Effective Learning Solutions:** She seeks resources that can address the diverse needs of students and provide differentiated instruction to support optimal learning outcomes.
- **Data-Driven Insights:** Dr. Bennett needs tools that offer detailed data and insights into students' progress, helping her refine her teaching methods and interventions.

"Empowering Education through Innovation: Nurturing Minds with Data-Driven Learning Solutions."

Bio

Dr. Olivia Bennett is a 50-year-old educational psychologist and researcher with a distinguished career in child development. She holds a Ph.D. in Educational Psychology and has published numerous articles and books on effective teaching methods for young learners. Dr. Bennett is a professor at a renowned university and is dedicated to shaping the future of education through research and innovative practices.

Personality

Introvert	Extrovert
Analytical	Creative
Loyal	Fickle
Passive	Active

Dr. Alan Roberts

Age: 38
Work: Researcher in AI
Family: 3 roommates
Location: Detroit, MI

"Elevating Education with AI: Where Innovation and Learning Converge for a Brighter Future."

Goals

- **Advancing AI Education**: Dr. Roberts is passionate about pushing the boundaries of AI to enhance educational experiences and create new opportunities for learning.
- **Research Excellence**: He is dedicated to conducting rigorous and impactful research that contributes to the advancement of AI and its applications in various domains.
- **Interdisciplinary Collaboration**: Dr. Roberts values collaboration with experts from diverse fields, believing that combining AI with other disciplines can lead to transformative breakthroughs.
- **Ethical Innovation**: He is committed to developing AI technologies that are ethically responsible and have a positive impact on society.

Bio

Dr. Alan Roberts is a 38-year-old computer scientist and AI researcher. He holds a Ph.D. in Artificial Intelligence from a prestigious university and has a strong track record of ground breaking research in machine learning and robotics. Dr. Roberts is known for his innovative thinking and his contributions to the development of cutting-edge AI technologies.

Frustrations

- **Real-World Application:** He is interested in AI projects that have practical applications and can address real-world challenges, particularly in the field of education.
- **Adaptive Learning:** He is intrigued by the potential of AI to provide personalized and adaptive learning experiences, catering to individual student needs and learning styles.
- **Data-Driven Insights:** Dr. Roberts requires access to detailed data and analytics to analyze the effectiveness of AI-driven educational tools and refine their algorithms.

Personality

Picky	Easy
Analytical	Creative
Introvert	Extrovert
Passive	Active

Preferred Channels

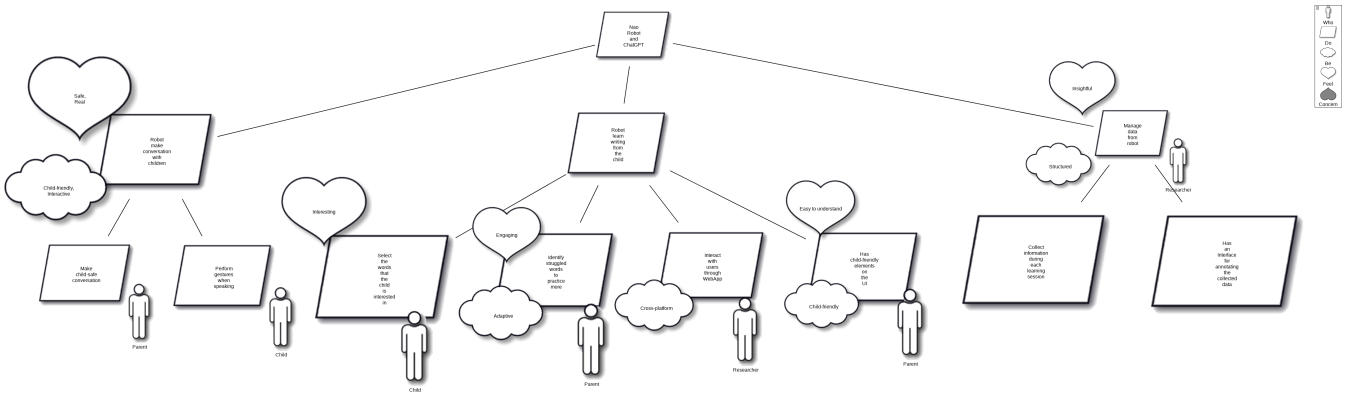
- Traditional Ads
- Online & Social Media
- Guerilla Efforts & PR

Goal Model

DO-BE-FEEL

WHO	DO	BE	FEEL
Child	Robot make conversation with children	Structured	Safe
Parent	Robot learn writing from the child	Child-friendly	Interesting
Researcher	Manage data from robot	Interactive	Engaging
	Make child-safe conversation	Adaptive	Real
	Perform gestures when speaking	Cross-platform	Easy to understand
	Select the words that the child is interested in		Insightful
	Identify struggled words to practice more		
	Has child-friendly elements on the UI		
	Interact with users through WebApp		
	Collect information during each learning session		
	Has an interface for annotating the collected data		

Goal Model



Link: https://momo-comp90082.eresearch.unimelb.edu.au

| Requirements

Prerequisites

Since it is a continued project from last semester and the client requested to review and merge the previous three projects to get started, comprehensive analysis and integration of past projects must be executed before implementing additional features as outlined in the User Stories section. We've taken into consideration the feedback from our supervisor that this integration process is not formally part of the user stories as it is not directly for the end-users. Accordingly, we have categorized it as "Prerequisites" instead. Smooth integration is a critical part as well as a primary goal of this project and can be further broken down into the following requirements below.

Note:

1) Priority is categorized as:

- **Must** - essential, non-negotiable features for the project's core functionality and success
- **Should** - not as critical as "Must", but important features that will significantly add up to the project's overall values
- **Could** - supplementary features that can enhance user experience, but can be omitted if sufficient time and resources are not allowed

2) Story points are allocated from the Fibonacci scale (0 - 89)

Requirement	ID	Specification	Priority	Story Point (0-89)	Acceptance Criteria				ChatGPT Generated
					Scenario	Given	When	Then	
Integration of previous projects	CS1	All three projects should be able to run under one unified environment and have no compatibility issues between each chunk of code	Must	47	Client receives the final project	Given that three previous projects have been developed under the same environment/upgraded to the same version	Execute three previous project separately in terminal	The code can run successfully in the new unified environment.	No
	CS2	All three projects should be merged into a single repository with features integrated	Must	72	Client tests the final project	Given that three projects have been merged into one repository	Execute the code as a whole project in terminal	Can run successfully with no errors as a whole project.	No
	CS3	All the merging and integration process should be documented in a structured and organised way	Must	7	Client/New developer review the final project	Given that a clear document shown on Github and each code meet the coding standard and clearly commented	Other new developer review our project and code	They are able to understand the code/function and the project without much effort.	No

User Stories

Note:

1) Priority is categorized as:

- **Must** - essential, non-negotiable features for the project's core functionality and success
- **Should** - not as critical as "Must", but important features that will significantly add up to the project's overall values
- **Could** - supplementary features that can enhance user experience, but can be omitted if sufficient time and resources are not allowed

2) Story points are allocated from the Fibonacci scale (0 - 89)

Epic	ID	User Story			Priority	Story Point (0-89)	Justification	Chat GPT Generated
Improvement of conversation using ChatGPT	US1	As a parent,	I want the robot to have a conversation with my kids in a child-friendly and safe manner	so that my child's interaction stays positive and free from inappropriate content.	Must	29	Ensuring a child-friendly and safe conversation is essential for the children's wellbeing, and keeping them away from potential harm and negative influence	No
	US2	As a child,	I want the robot to associate a human gesture to its conversation	so that I would feel like talking to a real person.	Could	21	This is an optional feature that will make the interaction between kids and robot more fun and immersive	No
Improvement of CoWriter	US3	As a parent,	I want my kids to be able to practice their struggling letters	so that the learning process can be more engaging.	Must	30	This will be a significant upgrade to the CoWriter software and will play a key role to make the writing practice more personalised and effective	No
	US4	As a parent,	I want to add more child-friendly elements to UI such as illustrations	so it helps kids to easily understand and remember the words	Could	34	This is an extra feature that will potentially help with children's vocabularay retention. This is yet remains as a "Could" priority as it's only a supplementary feature and not of an immediate critical need.	No
	US5	As a researcher,	I want to move the UI from PyQT to a web version (browser)	so that I can access via various platforms and devices without the need for download/installation	Should	35	This transition will provide end-users with increased accessibility, platform independence, and reduced download/installation barriers	No
	US6	As a child,	I want to be able to select the domain I'm interested in	so that the learning becomes more fun and engaging	Could	34	This is another optional feature that can contribute to more motivating and personalised learning environment for children	No

Feature Development

This section serves as an in-depth overview of the features developed during each sprint, accompanied by the demonstration video and test case results. For each feature, it will address implementation details, outlining the technical aspects and methodologies applied as well as evolution details and rooms for improvement if applicable.

Sprint 2 Features

Demo Video

The video showcasing the features developed during this sprint can be found **HERE.**

Test cases demonstrated in the demo video:

Test cases were executed for user stories that were fully completed during Sprint 2. Those that are continuing to the next sprint (CS1, CS2, CS3, US3) will be tested during Sprint 3.

Epic	ID	User Story			Acceptance Criteria				Test Result
					Scenario	Given	When	Then	
Improvement of conversation using ChatGPT	US1	As a parent,	I want the robot to have a conversation with my kids in a child-friendly and safe manner	so that my child's interaction stays positive and free from inappropriate content.	Alex(Child) is communicating with the robot	Given that some prompts are set for the robot's conversation function	An improper topic appears during the conversation	The robot can detect the improper topic/words and start a new topic which is child-friendly.	PASSED ▪ refer to 0:03:49 in the demo video
Improvement of CoWriter	US4	As a parent,	I want to add more child-friendly elements to UI such as illustrations	so it helps kids to easily understand and remember the words	Alex(Child) is practicing some words and having hard time remembering the words	Given that a function is designed for the robot, which use openAI to generate the image based on the input word	After Alex and robot agree on the word to write	A image will be generated automatically on the child interface and can be updated with the new writing word.	PASSED ▪ refer to 0:02:25 in the demo video

AI-Generated Image

OpenAI

OpenAI has pioneered advancements in artificial intelligence, particularly in natural language processing and computer vision. One of its standout features is the ability to generate high-quality images based on textual prompts, making it a valuable tool for developers seeking efficient and creative solutions for visual content.

Set up

At the current stage, the image will be generated by using the writing word. When the user puts the word in the box and clicks the 'send word to write' in the 'manger_ui' window, the OpenAI will generate the image based on that word and return the URL for the image. Then this image will be downloaded into the database(under the project folder) through the URL. If a new writing word has been entered, the image in the folder will be replaced.

When illustrating the AI-generated image on the "child_ui" window, the image will be loaded and plotted on the window. A timer is used to keep refreshing the image and keep the image updated when there is a change in writing word.

Prompt

According to the OpenAI, they've taken steps to limit DALL·E 3's ability to generate violent, adult, or hateful content. We believe that the image will be safe enough for the children. Therefore, only one prompt 'cartoon' is added to provide a childish AI-generated Image.

Further Improvement

1. The method of downloading the image into the project folder for illustration is not efficient and waste of memory. Therefore, we will try to illustrate the image directly through the URL.
2. In order to realise improvement 1, the event for generating an image should be held in the 'child_ui.py' instead of 'manager_ui.py'. The ROS node for generating the image will be designed.
3. It will take some CPU when using the timer to keep the image updated. Therefore, we are thinking of a more efficient way to control the updated image.
4. After several experiments on generating the image, though OpenAI has safety control for generating the image, it is still found that some images will not be proper for the children. More prompts will be added to generate a better child-friendly image.

Filtering & Moderation

NAO's conversation capabilities has been further improved by refined prompt engineering using **GPT-4**, OpenAI's latest and most advanced GPT model (as of September 2023), with its chat moderation supported by the **OpenAI's moderation API**. Using a moderation model along with fine-tuned prompt engineering was cruicial in order to ensure that the conversation between the robot and children stay kids-friendly and safe.

Prompt Engineering

- Use of chat completion API (currently supported in gpt-3.5-turbo or gpt-4 models) which allows for different roles within the chat including system, assistsant, and user
- Set NAO's persona using the system role to control how NAO is expected to respond to further user messages
- Include the user information (e.g. children aged between 5-10) to ensure using of age-appropriate langauge throughout the chat

Moderation Model

OpenAI's moderation API was used to filter and moderate input to ensure that it meets safety and content guidelines. Every input chat or audio from children will be passed to this moderation model and will receive an output like the example below. As you can see, the input will be evaluated based on multiple different categories such as hate, harrassement, violence etc. We used the "category_scores" result as it allows for more customised and refined filtering than the "flagged" result which is just a boolean value. We have set a relatively strict threshold (=0.05), and if the input scored any of these category scores higher than this threshold, it will be marked as flagged. In this case, the robot will redirect the conversation to a more child-friendly topic.

Output Example


```
{
  "id": "modr-XXXXX",
  "model": "text-moderation-005",
  "results": [
    {
      "flagged": true,
      "categories": {
        "sexual": false,
        "hate": false,
        "harassment": false,
        "self-harm": false,
        "sexual/minors": false,
        "hate/threatening": false,
        "violence/graphic": false,
        "self-harm/intent": false,
        "self-harm/instructions": false,
        "harassment/threatening": true,
        "violence": true,
      },
      "category_scores": {
        "sexual": 1.2282071e-06,
        "hate": 0.010696256,
        "harassment": 0.29842457,
        "self-harm": 1.5236925e-08,
        "sexual/minors": 5.7246268e-08,
        "hate/threatening": 0.0060676364,
        "violence/graphic": 4.435014e-06,
        "self-harm/intent": 8.098441e-10,
        "self-harm/instructions": 2.8498655e-11,
        "harassment/threatening": 0.63055265,
        "violence": 0.99011886,
      }
    }
  ]
}
```

Migration: ROS1 to ROS2

"The Robot Operating System (ROS) is a set of software libraries and tools for building robot applications. From drivers and state-of-the-art algorithms to powerful developer tools, ROS has the open source tools you need for your next robotics project." (ROS Documentation)

The version we used for the upgrade is the **ROS2 Humble**, released in May 2023.

This page gathers the the most common updates that had to be made to the code to upgrade the ROS version, but also some general information about developing in the ROS development.

Note: this page will be focusing about Python ROS packages since it was our main coding language for this project.

ROS2 Python Packages

Organisation

To create a new Python ROS package, run the command

```
ros2 pkg create --build-type ament_python <name-of-the-package>
```

It will be composed of a least 5 main elements:

- a `setup.py` file containing the definition of the module and the dependencies specific to Python, but also the definition of the nodes (their name, the corresponding file and)
- a `package.xml` file which is the equivalent of `setup.py` but for the ROS dependencies
- a `setup.cfg` file to store options for the `setup.py` file
- a `resource` folder containing an empty file named after the package (essential when building the package)
- a source folder (named after the name of the package)which will contain the source code of the package.

Contrary to ROS1, pure Python ROS2 packages do not need to have a `CMakeLists.txt` file.

For more information about the files, see the documentation here.

The architecture is the following:

```
<package-name>/
 package.xml
 setup.py
 setup.cfg
 resource/
    <package-name> (the empty file)
 <package-name>/
    ... (Python source files)
 test/
     ... (test files)
```

Moreover, the nodes contained in the package can be launched at the same time using a `.launch.py` file. It should be placed in the resource folder of the package. For more information about launch files, see here.

Build and Run

To build a pure Python ROS2 package, run the following commands:

```
sudo colcon build --packages-select <package-name>
# when it is done
source ./install/setup.bash
```

To run one node:

```
ros2 run <package-name> <the-name-of-the-node>
```

To launch the package (if it contains a `.launch.py` file):

```
ros2 launch <the-package-name> <the-name-of-the-launch-file>
```

Main changes in ROS2 (Python)

Node implementation

The common practice to build a node in ROS2 is to create a class inheriting from the `Node` object of `rclpy` . Each node should have:

- its own file, containing a `main` function. This function will be declared in the `setup.py` file
- a name

For example (`example_node_file_name.py` file):

```
import rclpy
from rclpy.node import Node

class ExampleNode(Node):
        def __init__(self):
                super().__init__("example_node_name") # name declaration
        ...

def main(args=None):
    rclpy.init(args=args)

    example_node = ExampleNode()

    rclpy.spin(example_node) # launch the node

    example_node.destroy_node() # destroy the node when the process is ended
    rclpy.shutdown()


if __name__ == "__main__":
    main()
```

To declare this node, the following line should be added in the `setup.py` file:

```
from setuptools import setup

package_name = "example_package_name"

setup(
    ...,
    entry_points={
        "console_scripts": [
            "example_node_name = example_package_name.example_node_file_name:main",
                        # ... other nodes
        ],
    },
)
```

Subscriber / Publisher

To communicate, the nodes use a publisher/subscriber system. The publishers send messages to a specific topic. The subscribers listen to these topic messages and launch specific commands (callbacks) depending on what they receive.

The ROS2 documentation offers a really educational tutorial about this topic here.

Handling multithreading with ROS2 nodes

Once a node is launched using `rclpy.spin` , the `main` function will not execute any code declared after.

In order to execute a program in parallel of a node (a GUI for example), the programs can be launched in different threads. For example:

```
from threading import Thread
from rclpy.executors import MultiThreadedExecutor

...

### NOT WORKING
def main(args=None):
    rclpy.init()

    gui = GUI()
    node = GUINode(window)

        # here, the GUI starts first -> the node will not be spinned
    gui.start()
        rclpy.spin(node)

         # here, the node starts first -> the gui will not start
          rclpy.spin(node)
         gui.start()

### SOLUTION: create a distinct thread for the node
def main(args=None):
    rclpy.init()

    gui = GUI()
    node = GUINode(window)

    executor = MultiThreadedExecutor()
    executor.add_node(node)

    thread = Thread(target=executor.spin)
    thread.start()
    node.get_logger().info("node spin")

    try:
        gui.start()

    finally:
        node.get_logger().info("Shutting down ROS2 Node . . .")
        node.destroy_node()
        executor.shutdown()
```

Using the NAOQi SDK with ROS2

The NAOQi SDK establish the communication between Python and the NAO robot (either virtual or real) using Choregraphe. This SDK has no existing distribution for ROS Humble and is running under Python2.7 (ROS2 is Python3).

In order to establish the communication between the ROS code and the SDK code, we need an interface: Python2.7 and Python3 cannot coexist in the same environment.

We chose to use Python Flask to create a small API, acting like a bridge between the two processes. It functions as follows:

- for example, a node will compute a new trajectory for the robot's arm
- the trajectory will be sent from the node to the API using one of its routes
- the API will execute the code linked to that route and inform the SDK about that trajectory
- the SDK will send the trajectory to Choregraphe.

To ease the development and the deployment of our source code, both environment have been containerised using Docker. Therefore, the two distinct Python environments are well isolated from each other.

Struggle letter Module

Demo video here: https://www.youtube.com/watch?v=RNiRpzP787M

This folder consist of two method:

1. CNN based see in "CNNbased.py", in NAO writing project, we do not apply it to our struggled letter identify module, because it still in a low accuracy.
2. Mutil-attributes based see in "main.py", "robot_write.py", and "ssim_similarity.py".

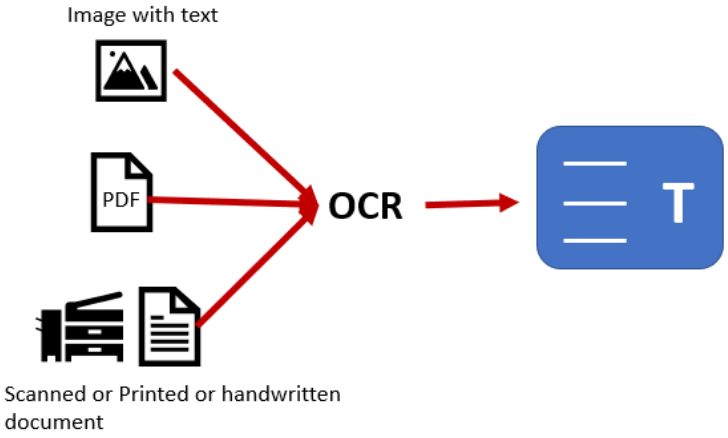
   Intro of three file:

   2.1 "robot_write.py": this file only consist of a robot writing board. In this project, it will be pretended as a auto robot writing area.

   2.2 "main.py": this file allow children type the letter they wanna practice and a area to write the letter. It also provide a button called "if a good writing" to generate the feedback for child writing.

   2.3 "ssim_similarity.py": this is the main function of how to rate the hand writing and it consists of OCR , MSE, SSIM, Hamming Distance to measure the handwriting.

   OCR (Optical Character Recognition): Optical Character Recognition (OCR) is a technology that is used to convert printed or handwritten text into machine-encoded text. The primary purpose of OCR is to recognize and digitize text from physical documents, such as scanned paper documents, images, or even text in natural scenes, making it accessible for digital storage, editing, and analysis.



MSE (Mean Squared Error): It is a common metric used in statistics, machine learning, and image processing to measure the average squared difference between the values predicted by a model or system and the actual observed values. MSE is often used as a measure of the quality of a predictive model or as a cost function to be minimized during the training of machine learning algorithms.

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(Y_i - \hat{Y}_i)^2$$

SSIM (Structural Similarity Index): It is a widely used image quality assessment metric that quantifies the structural similarity between two images. SSIM is designed to capture perceived changes in structural information, luminance, and contrast, making it a valuable tool for comparing the visual quality of images.

$$SSIM(x,y) = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x + \sigma_y + c_2)}$$

Hamming Distance: Hamming Distance is a metric used to measure the difference between two equal-length binary strings or sequences. It calculates the minimum number of substitutions required to change one string into the other. Hamming Distance is often used in information theory, coding theory, error correction, and digital communications.

Hamming Distance

$$D_H = \sum_{i=1}^{k} |x_i - y_i|$$

Overall method of measure handwriting:

weight sequence = [["OCR", Ture or False (0 or 1)] , ["MSE", float from 0 to 1] , ["SSIM", float from 0 to 1] , ["Hamming Distance", float from 0 to 1]]

Overall = weight[OCR] x OCR - weight[MSE] x MSE + weight[SSIM] x SSIM - weight[Hamming Distance] x Hamming Distance

NOTE: the number of these three attributes has been normalised into range[0,1] the weight for three attribute can be adjust manually, if you want, but you also need to adjust the threshold of struggled letter.

Sprint 3 Features

Demo Video

The video showcasing the features developed during this sprint can be found **HERE.**

Test cases demonstrated in the demo video:

Epic	ID	User Story			Acceptance Criteria				Test Result
					Scenario	Given	When	Then	
Improvement of conversation using ChatGPT	US2	As a child,	I want the robot to associate a human gesture to its conversation	so that I would feel like talking to a real person.	Alex(Child) want to communicate with robot in a lively way	Given that some new gestures are designed in ROS for the robot	After Alex talking to the robot, during the reply to Alex from the robot	The robot can find the gesture in the list corresponding to the emotion/keyword of the chatGPT-generated words and can move smoothly based on the command, which is designed in ROS.	PASSED • refer to 0:00:01 - 0:00:20 in the demo video
Improvement of CoWriter	US6	As a child,	I want to be able to select the domain I'm interested in	so that the learning becomes more fun and engaging	Alex(Child) is bored with writing words in the list, he want to communicate with the robot in his interested domain and write the words which are related to his interests	Given that the robot will ask children's interest directly through conversation based on the chatGPT and find the children's information in the database	Alex starts to communicate with the robot	The robot can identify the interest through the conversation with the children and provide the a word to write which are related to Alex's topic of interest.	PASSED • refer to 0:00:00 - 0:00:55 in the demo video

NAO Conversation

The previous projects have implemented Robot conversation functionality. However, for Boxjelly and Redback, it is required to press a button before speaking to the robot. While Bluering, they are able to communicate with the robot directly. We integrated and improved the module base on Bluering's project.

The conversation module utilize the following libraries:

Google Speech-to-Text

ROS2 audio capture

When the robot is waiting and it is not writing, we signal the robot to listen. We obtained the audio data captured from audio capture node. If the audio data is louder than a threshold, then it indicates that someone is talking to the robot. We keep buffering the audio data until a continuous silent and send the audio buffer to Google speech-to-text to transfer into transcript. Then, we send the transcript to our phrase manager module to generate Robot response.

NAO Motion Generation

ALAnimationPlayer allows creating, customizing, and executing animations. We used this service to make NAO to take human-like motions and geatures during the interaction with kids. Understanding the context of message and deciding what types of motions to take are determined by ChatGPT.

The overall process of motion generation is as of below:

1) phrase_manager.py returns the response message from ChatGPT that NAO is going to say

2) The response message will be then passed to the ChatGPT to decide the types of motions to take among the keys available in the motions dictionary. It will return "none" if no suitable context match is found (which in this case, no motion will be executed).

3) Given the motion key, it will randomly select among the available paths (values for the corresponding key) and return the path.

Structure of motions directionary:

```
        motions = {
            "greeting" : [
                "animations/Stand/Gestures/Hey_1",
                "animations/Stand/Gestures/Hey_6"
            ],
            "affirmation" : [
                "animations/Stand/Gestures/Yes_1",
                "animations/Stand/Gestures/Yes_2",
                "animations/Stand/Gestures/Yes_3"
            ],
            "interrogative" : [
                "animations/Stand/Gestures/YouKnowWhat_1",
                "animations/Stand/Gestures/YouKnowWhat_5"
            ],
            "joy" : [
                "animations/Stand/Gestures/Enthusiastic_4",
                "animations/Stand/Gestures/Enthusiastic_5"
            ],
            "hesitation" : [
                "animations/Stand/Gestures/IDontKnow_1",
                "animations/Stand/Gestures/IDontKnow_2"
            ],
            "refusal" : [
                "animations/Stand/Gestures/No_3",
                "animations/Stand/Gestures/No_8",
                "animations/Stand/Gestures/No_9"
            ]
        }
```

Rooms for improvement:

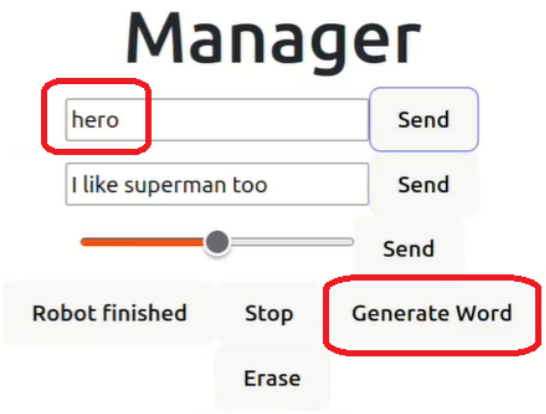
- More animations can be tested to further diversify the motoin feature
- Currently, the motions work with the physical robot only. When testing on a virtual robot on Choregraphe, the motion path is not being recognised. Different paths may be required for the virtual robot.

Personalised Words Generation

A new feature to automatically generate personalised words has been implemented during Sprint 3. This is mainly to make the learning experiences more fun and engaging for children while making it more convenient for managers (researcheres in this case) by automaticallly generating a word rather than manually typing it.

When managers click the "Generate Word" button on their UI (see the screenshot image below), a message history between a child and robot during the learning session will be passed to ChatGPT to extract/update the child's interest. Based on the interest, a short and kids-friendly word will be generated from ChatGPT and will be displayed in the text-to-write input field (top input text field). Then the manager can review the word and publish it ("Send" button) or click on the "Generate Word" button again to generate a new word.

Manager UI example:



Struggle Letter Module (Version2)

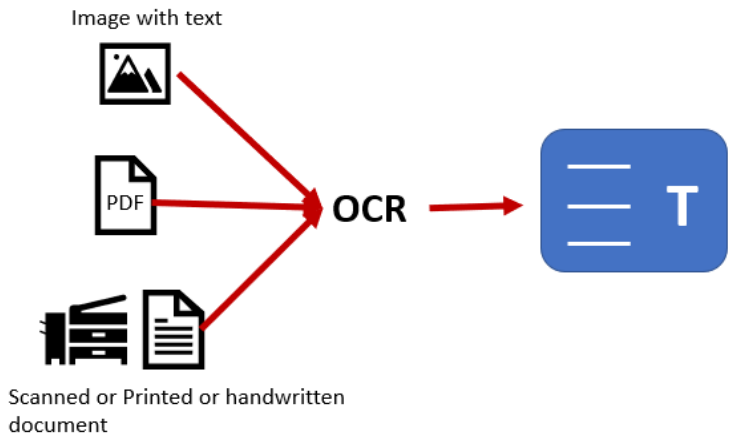
Overall method of measure handwriting:

weight sequence = [["OCR", Ture or False (0 or 1)], ["fastDTW", float from 0 to 1] , ["Hamming Distance", float from 0 to 1]]

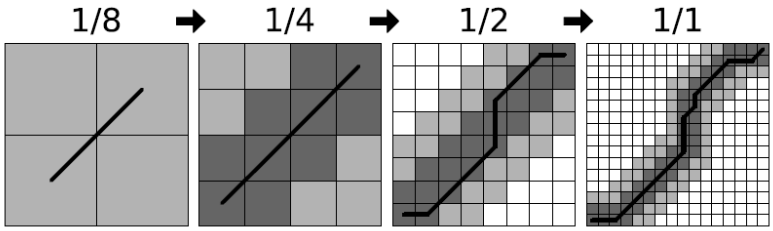
Overall = weight[OCR] x OCR - weight[fastDTW] x fastDTW - weight[Hamming Distance] x Hamming Distance

NOTE: the number of these three attributes has been normalised into range[0,1] the weight for three attribute can be adjust manually, if you want, but you also need to adjust the threshold of struggled letter.

OCR (Optical Character Recognition): Optical Character Recognition (OCR) is a technology that is used to convert printed or handwritten text into machine-encoded text. The primary purpose of OCR is to recognize and digitize text from physical documents, such as scanned paper documents, images, or even text in natural scenes, making it accessible for digital storage, editing, and analysis. In Sprint 3, the OCR module's accuracy is improved by using outsoursed API. You can register one through https://rapidapi.com/serendi/api/pen-to-print-handwriting-ocr



***FastDTW*:** FastDTW is a Python library for approximate dynamic time warping (DTW) calculation. DTW is a technique used for measuring the similarity between two sequences that may vary in time or speed. FastDTW is an approximate and faster version of DTW that is suitable for large datasets.



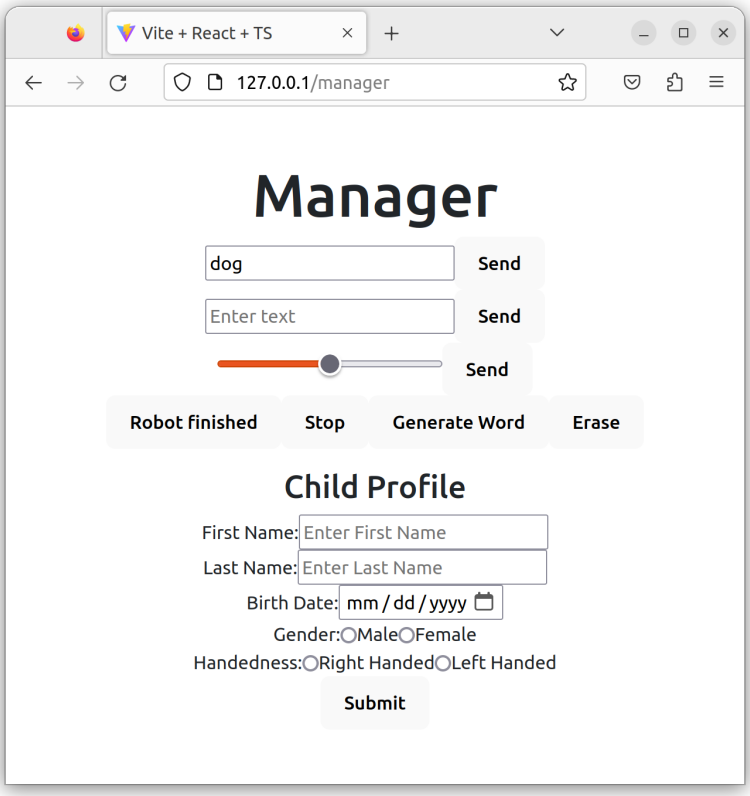
Hamming Distance: Hamming Distance is a metric used to measure the difference between two equal-length binary strings or sequences. It calculates the minimum number of substitutions required to change one string into the other. Hamming Distance is often used in information theory, coding theory, error correction, and digital communications.

Hamming Distance

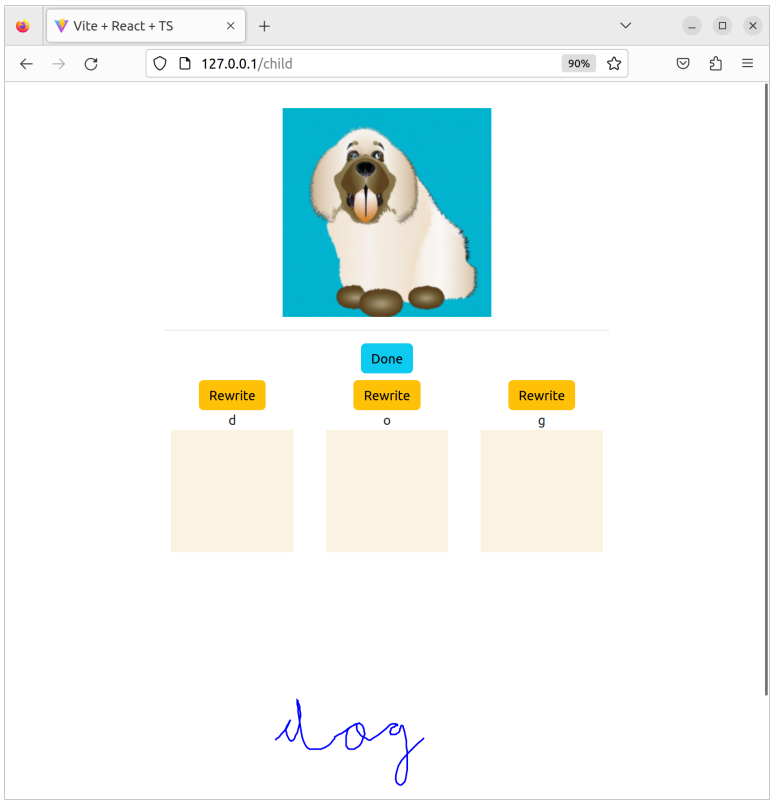
$$D_H = \sum_{i=1}^{k} |x_i - y_i|$$

UI Migration to Web

Manager UI



Child UI


Vite + React + TS
127.0.0.1/child
90%
Done
Rewrite
d
Rewrite
o
Rewrite
g
dog

Acceptance Criteria

Priority is categorized as:

- **Must** - essential, non-negotiable features for the project's core functionality and success
- **Should** - not as critical as "Must", but important features that will significantly add up to the project's overall values
- **Could** - supplementary features that can enhance user experience, but can be omitted if sufficient time and resources are not allowed

Prerequisites

Requirement	Acceptance Criteria ID	Prerequisites ID	Specification	Priority	Acceptance Criteria			
Integration of previous projects	AC01	CS1	All three projects should be able to run under one unified environment and have no compatibility issues between each chunk of code	Must	Client receives the final project	Given that three previous projects have been developed under the same environment/upgraded to the same version	Execute three previous project separately in terminal	The code can run successfully in the new unified environment.
	AC02	CS2	All three projects should be merged into a single repository with features integrated	Must	Client tests the final project	Given that three projects have been merged into one repository	Execute the code as a whole project in terminal	Can run successfully with no errors as a whole project.
	AC03	CS3	All the merging and integration process should be documented in a structured and organised way	Must	Client /New developer review the final project	Given that a clear document shown on Github and each code meet the coding standard and clearly commented	Other new developer review our project and code	They are able to understand the code/function and the project without much effort.

User Stories

Epic	Acceptance Criteria ID	User ID	User Story			Priority	Acceptance Criteria			
							Scenario	Given	When	Then
Improvement of conversation using ChatGPT	AC04	US1	As a parent,	I want the robot to have a conversation with my kids in a child-friendly and safe manner	so that my child's interaction stays positive and free from inappropriate content.	Must	Alex(Child) is communicating with the robot	Given that some prompts are set for the robot's conversation function	An improper topic appears during the conversation	The robot can detect the improper topic/words and start a new topic which is child-friendly.
	AC05	US2	As a child,	I want the robot to associate a human gesture to its conversation	so that I would feel like talking to a real person.	Could	Alex(Child) want to communicate with robot in a lively way	Given that some new gestures are designed in ROS for the robot	After Alex talking to the robot, during the reply to Alex from the robot	The robot can find the gesture in the list corresponding to the emotion /keyword of the chatGPT-generated words and can move smoothly based on the command, which is designed in ROS.
Improvement of CoWriter	AC06	US3	As a parent,	I want my kids to be able to practice their struggling letters	so that the learning process can be more engaging.	Must	Alex(Child) writes some letter badly	Given that some new machine learning methods are used in the robot and the robot is trained with enough data	After Alex writing a letter	The robot can find the bad letters written by Alex and generate some new words which contain those bad letters.
	AC07	US4	As a parent,	I want to add more child-friendly elements to UI such as illustrations	so it helps kids to easily understand and remember the words	Could	Alex(Child) is practicing some words and having hard time remembering the words	Given that a function is designed for the robot, which use openAI to generate the image based on the input word	After Alex and robot agree on the word to write	A image will be generated automatically on the child interface and can be updated with the new writing word.

	AC 08	US5	As a researcher,	I want to move the UI from PyQT to a web version (browser)	so that I can access via various platforms and devices without the need for download /installation	Should	Olivia(Researcher) want to access the project through Web, because the pad is not working	Given that all the backend software are connected to the UI in the web	After Olivia launching the project	He can access to the manager ui and child ui locally through the browser and all the function can be executed on browser successfully.
	AC 09	US6	As a child,	I want to be able to select the domain I'm interested in	so that the learning becomes more fun and engaging	Could	Alex(Child) is bored with writing words in the list, he want to communicate with the robot in his interested domain and write the words which are related to his interests	Given that the robot will ask children's interest directly through conversation based on the chatGPT and find the children's information in the database	Alex starts to communicate with the robot	The robot can identify the interest through the conversation with the children and provide the a word to write which are related to Alex's topic of interest.

| Final Product

Presentation Slides

The slides are available to download here.

Product Video

YouTube: COMP90082_2023_SM2_NA_RedBack_Final_Video

Canva: Canva_Final_Video

| Handover

All the source code, the documentation and all the other project related documents is available [here].

| Development

Software Processes Management

The following technologies will be used by the team to support the software development processes:

- **Trello** to track and manage development tasks (our Trello board);
- **Confluence** to store all the useful resources linked with the project (meeting minutes, documentation …) ;
- **Slack** as an external communication tool to interact with our supervisors and clients (the team decided to use **Discord** for internal communication) ;
- **Zoom** to host meetings with our supervisors and clients ;
- **GitHub** as a DevOps tool to update and manage the source code of the project (our GitHub repository).

Previous Projects - Setup & Tests

The work we will conduct this semester constitutes the developments of three projects which were conducted last semester (BlueRing, BoxJelly and RedBack). Following in from these three projects, we propose to use the same stack to develop our new source code on the top of the existing one. Indeed, the technologies used last semester are (almost) the same for each team.

The main part of the stack will be composed of:

- Linux (**Ubuntu**) for the operating system ;
- **ROS** (Robot Operating System) used for communication the robot and the Python controlling module ;
- **Python3** to develop the new functionalities for the robot.

Nevertheless, even though the objectives were similar for each of the previous teams, we noted differences in the versions of the softwares used and in the installation instructions. This is why **containerizing applications**, such as Docker, could represent a powerful tool to set a single and stable coding environment.

This approach will have two main advantages:

- No compatibility issues will be encountered by the team during the development phase (the code developed by one team member will be executable by any other) ;
- The environment will already be defined for the future teams involved on this project.

Comparing Projects

Our first step will be to compare the three projects.

Last semester, each team have been either:

- updating existing modules (ex: upgrade Python's version)
- modifying existing modules so they could fir their source code
- developing new source code.

For the two first previous points, even if the teams started with the same source code, it is not said that they made the same changes/improvements. Two quick ways to compare files can be:

- if there is only one file to compare, VisualStudioCode (| Tools) allows a user to compare two files (more information here)
- if multiple files need to be compared, it might be wise to use Git: for example, create a first branch with the files from TeamA, an other one with the files from TeamB and create a pull request. The differences between the files will be shown.

General Remarks

Overall, it was not an easy task to run the three previous projects, even with the documentation provided by each team. In most cases, issues we encountered were dealing with incomplete or missing installation instructions. Because of this, we spent a lot of time setting up the environment for each project.

To overcome these issues, we decided to create a specific Docker image for each project which contains all the installation instructions required to launch their respective source code. Even if the build time was really long (around an hour for Boxjelly and Bluering), it appeared to be the most effective method. Indeed, in (almost) all cases, if the encapsulated code worked on one of a team member's laptop it would work on the other machines too.

The "almost" in the previous sentence refers to two issues we encountered:

- with Docker Desktop (Ubuntu): we had issues with ports and permissions to access the virtual robot, but after uninstalling Docker Desktop and installing only Docker, the issue was resolved
- with the system architecture (described on | Deployment): some Python modules which require a lot of resources (like Tensorflow) result in code crash on Macs (error: Illegal instruction - core dumped).

Bluering

General Remarks

Probably the hardest project to run. We are still facing Python errors while running the source code.

The installation required a lot of rework and research to fix issues encountered due to missing or too generic instructions.

The issues we faced were the following:

- The ROS dependencies were only listed as bullet-points containing only a link to the GitHub source code of the modules. No instructions on how and where to include these modules in the source code were provided.
- For one of the ROS dependencies (gscam), one file has to be downloaded from GitHub and added in a specific directory to make the code run (no mention of this in the documentation).
- No list of the required Python modules was given (similar to Redback). To know which modules were missing, we just ran the code updating the module list, until it would run without any import error. For this point, we faced the architecture error (mentioned on General Remarks) after the installation and import of Python Tensorflow: the Mac users cannot run the code any further.
- Import and attribute errors for Python modules, which can be linked to the previous point (some specific version of modules might need to be installed).
- Declaration of environment variables (for example, which paths needs to be added to the .bashrc file). In addition, in order to build or run the project, a source command needs to be executed before calling ROS specific functions.
- We noticed that the exact same lines codes were commented in Boxjelly but not in Bluering. If they are not commented, the Bluering project cannot be ran (we need to investigate on this point because it might come from the fact we only tested the code with the simulated robot for now).

We provided the Dockerfile and the installation/run commands on one of our branches here.

Boxjelly

General Remarks

For this project, the installation instructions were the most precise and complete ones compared to the two other teams. They even provided an auto-installation script which can run all the installation instructions.

But if we still faced some issues installing the environment manually, mostly because some required Python modules did not appear in the requirements file.

Moreover, since Bluering and Boxjelly share almost the same installing instructions, we were able to reuse some parts of the developed Dockerfiles, which sped up the environment setup.

We provided the Dockerfile and the installation/run commands on one of our branches here.

Redback

General Remarks

This project was the easiest one to run, in particular for the GUI module for which the team created a Docker image (as soon as Docker is installed, one command is enough to run the code).

Nevertheless, we still encountered the following issues:

- missing installation instructions, especially the list of the required Python modules (listed in a requirements.txt file for example). To know which modules were missing, we just ran the code updating the module list, until it would run without any import error
- declaration of environment variables (for example, which paths needs to be added to the .bashrc file).

We provided the Dockerfile and the installation/run commands on one of our branches here.

| Coding Standards

Branch Naming

The Git branching model used for this project will be Gitflow Workflow.

The general idea of this workflow is to work with 2 principal branches:

- *main* which will host the tested and finalised source code ;
- *develop* which will serve as a feature integration branch to test new releases before merging them on main.

The other branches will be named according to the following convention:

- *feature*: used to develop new features or enhancements (created from develop)
- *release*: used to prepare for a new production release (created from develop)
- *hotfix*: used to quickly patch production releases (only branch type to be created from main)
- (*support*: used for versions of software that are still supported but are not the latest version).

More information about this workflow is available here.

Code Formatting

Most of our code development will be Python, so the coding standards used for this language will be the following:

- PEP8 for all the coding conventions (ex: syntax checking, best practices)
- Black for code formatting automation (ex: maximum character number per line).

To ensure that the code pushed is consistent with the chosen Python standards, a GitHub Action has been set on the repository.

At each commit, a pipeline will be triggered. It will execute a command (module Flake8) to check if each specified Python file complies with PEP8's rules.

If the pipeline should fail, it would mean some changes have to be made to ensure the consistency of the source code.

| Docker - Overview

In order to encapsulate the environment of our project, we chose to use Docker.

Docker is platform that allows developers to *containerise* applications. It means that all the developed code, along with its dependencies, is executed in a closed and isolated environment called a "container".

Contrary to virtual machines, the containers are built on top of the operating system of the host, they are more light weighted.

Docker Objects

Docker concepts mainly rely on two objects, **images** and **containers**.

Docker Images

An image is a list of instructions that will help creating containers. Images are often built on the top of an existing one (the ROS Humble in our case), and developers will add their own instructions to adapt it to their project requirements.

Images are built from a `Dockerfile` . This file will contain the customisation instructions described above.

For example, if the project requirements specify to:

- use the Humble version of ROS
- install Python Tensorflow

the `Dockerfile` will be structured as follow:

```
FROM ros:humble # base image

# the image only contains the minimal requirements to run ROS, so we need to install pip3
RUN apt-get update && apt-get install -y python3-pip
RUN pip3 install tensorflow
```

Many other commands like `RUN` are available to build Docker images, this page list them all.

When the `Dockerfile` is ready, the image has to be built using the `docker build` command (documentation here). During the build, all the instructions listed in the Dockerfile will be executed and stored: the aggregation will compose the final image.

Docker Containers

After building the image, containers (instances of the image) can be created and deployed.

As described above, a container hosts an environment that is constructed based on the sequence of commands specified in the `Dockerfile` .

Containers can be created and launched using the `docker run` command (documentation here).

They can also be executed (documentation here), if you want to log in the container and execute bash commands for example (useful for debugging).

Installation

Installation instructions are listed in the | Deployment.

(based on Docker's documentation, available here for more details)

| Tools

This section presents the recommended tools and commands each team member should use to ease the code development:

- the choice of the IDE
- how to Develop inside Containers

View the section | Testing to launch, test and debug the developed ROS code.

IDE

We recommend to use VisualStudioCode as IDE (Integrated Development Environment). Indeed, it is possible to install extensions (for syntax highlighting for example) which will automatically format the code or warn the user if one of the chosen coding standards mentioned above are not respected (| Coding Standards).

To install an extension, click on this button  (it is located on the left navigation bar). Then, search the extension in the Marketplace and install it.

The following extensions should be installed (at least):

- Black Formatter
- Flake8
- Pylance
- Python

After installing these extensions, some configuration is needed.

In VisualStudioCode, go to the settings: Code > Settings > Settings (more information here). Then, click this button  (it is located at the top right of the screen). That button will open a file (`settings.json`) which allows a user to edit the settings manually.

Add the following lines to that file:

```
// each time a Python file is saved, Black will format it
"[python]": {
    "editor.formatOnSave": true,
    "editor.defaultFormatter": "ms-python.black-formatter"
    },
// how many characters per line in Python files
"black-formatter.args": [
    "--line-length",
    "80"
    ],
"flake8.args": [
    "--max-line-length",
    "80"
    ]
```

We also recommend to install the following extensions:

- Docker extension: to easily manage Docker images and containers if you are not familiar with this development tool (or download Docker Desktop Docker Desktop)
- Dev Containers: to enable the possibility of using containers as a development environment (view Develop inside Containers for more details)
- Github Actions for VSCode: to manage GitHub workflows (CI/CD).

Develop inside Containers

For this project, we chose to use Docker to encapsulate our environment (Python modules required, ROS software ...).

If you are not familiar with Docker and its concepts, we recommend you to read | Docker - Overview first.

Using the extension Dev Containers, it is possible to use a running container "as a full-featured development environment". It will open a VSCode window "remotely" so that the files located inside the container will be accessible and easily editable.

This development method has many advantages:

- Reproducibility and Consistency: the environment setup is consistent and does not differ from a developer to an other. Therefore, if a developer requires to install a new Python module during his development phase for example, any other developer from the team can integrate his changes by re-building or pulling the new Docker image
- Onboarding: when a new developer joins the team, his onboarding would be faster than if he had to run all the environment setup instructions. He would only need to clone the Git repository and build or pull the associated Docker image
- All the VSCode features become available in the container environment (for example, code autocomplete using the Python extension).

How to use the extension (video tutorial available here):

First, build the image containing your environment:

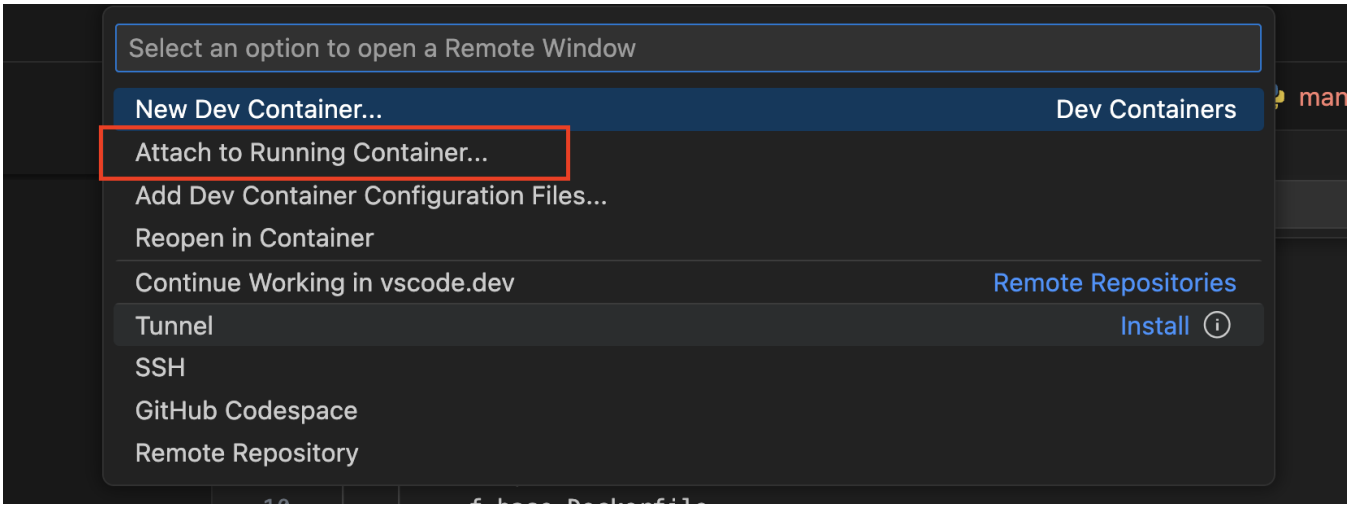
```
docker build --tag <your_image_name> --platform linux/amd64 -f <Dockerfile_name> .
```

Then, run a container which will host that environment:

```
# careful with which user you are using inside the container (option --user)
# in general, using root can be dangerous when volumes are used
docker run -it \
                --name <your_container_name> \
                --user <user> \
                --network=<docker_network> \
                -v <path_on_host>:<path_in_container> \
                <your_image_name> bash
```

Note: the v option (volume) will create a link between the selected folder of the host (for example, the src folder of your project) and the folder of the container. So every changes made inside the container using the extension will be transferred on the host and vice versa (find more information on Docker's documentation here).

Now that the container is running, we can attach a VSCode to it. Click the button  located at the extreme bottom left of your VSCode window. It will open a dialog window: select Attach To Running Container and click on the name of the controller launched during the previous step.

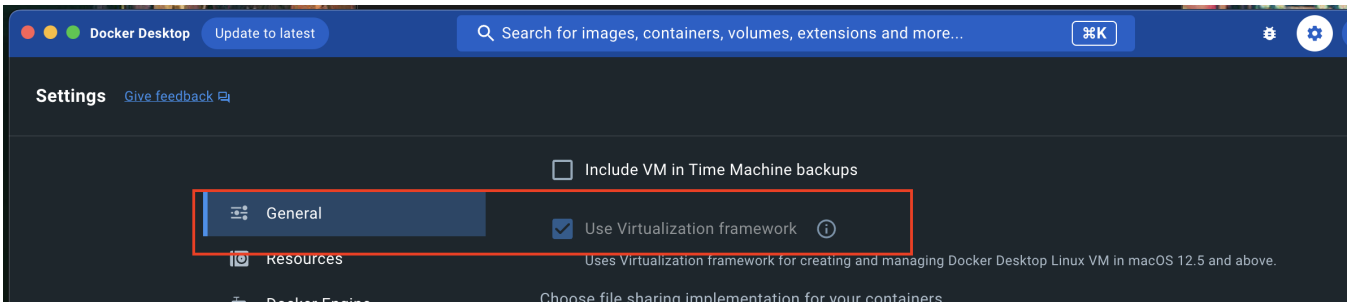


Finally, install the recommended extensions (see above) in your container.

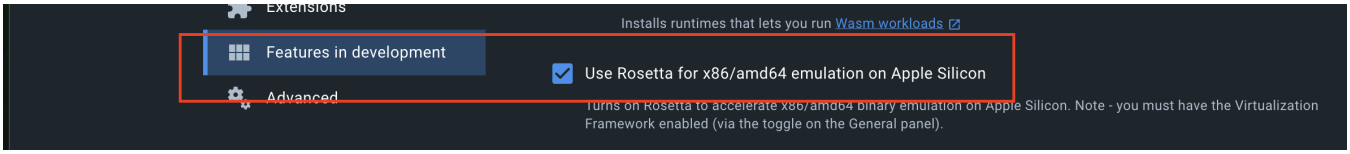
Note for M1 and M2 Mac chips users:

By enabling:

- the "Virtualization Framework"



- the "Use Rosetta for x86/amd64 emulation on Apple Silicon" option in the "Features in development"



in Docker Desktop's settings (directly on your Mac, not in Ubuntu), it is possible to launch and build amd64 Docker images by adding a tag `--platform linux/amd64` for each Docker command ran (see the documentation here).

Thereby, the development environment will be accessible even without using Ubuntu. It will be useful to develop code and do a bit of debugging, but not to test it on the robot as mentioned in | Deployment.

| Testing

Requirements: Docker and `make` are installed on the Ubuntu instance.

To check if `make` is installed:

```
which make
# if the output is "/usr/bin/make", then skip the following commands
# if not, run
sudo apt-get update
sudo apt-get install -y make
```

Debugging/Testing code inside an ROS Docker environment (video tutorial available here)

Launch the development environment

1. Clone the repository:

```
git clone git@github.com:COMP90082-2023-SM2/NA-Redback.git
cd NA-Redback
```

2. Set the `ENV` variable to "development":

```
export ENV=development
```

3. Build the development images:

```
make compose-build
```

Note: once the images are built, you do not need to execute this step again except if you change the environment (ex: installation of a new Python module).

4. Prepare the `.env` file:

See the Third-party API keys page.

5. Launch the containers:

```
make compose-up
```

To access the web application, open your browser and navigate to the following URL: `http://localhost:3000`

If you want to change the environment:

Modify the Dockerfile accordingly then remove the corresponding containers:

Then, execute steps 3, 4 and 5.

Develop in the environment

Once the containers have been created and **are running**, you can access the code inside it either by:

- opening a VSCode window using the Dev Container extension (Develop inside Containers). When the window is opened, open a terminal (ctrl+J or cmd+J), then on the prompt type `bash` and press enter
- executing the container (eg. log inside it) by running in a terminal window:

```
# note: before executing this command, the container must already be running
docker exec -it <the-name-of-the-container> bash
```

Test & Debug in the environment (ROS)

All the following commands are meant to be ran inside the container, eg. in the terminal window opened by either of the two possible options presented above.

Since the source code of the project is only "linked" to the container, none of the ROS packages have been built. To test and debug the code, the packages need to be built then launched in the container.

Ensure that the ROS environment variables are loaded:

```
source /opt/ros/humble/setup.bash
which ros2
# the output should be "/opt/ros/humble/bin/ros2"
```

Navigate to the same level as the `src` folder to build the desired ROS packages:

```
colcon build --packages-select <the-package-name>
```

Add the package's path to the environment variables:

```
source ./install/setup.bash
```

The nodes / package can now be tested:

- to run a single node, run:

```
ros2 run <the-package-name> <the-name-of-the-node>
```

- to run all the nodes at the same time (if the package contains a `.launch.py` file:

```
ros2 launch <the-package-name> <the-name-of-the-launch-file>
```

If you modify the source code of the package, rebuild it and run the node / the package again. If the package is not rebuilt, the changes will not be taken into account.

Test & Debug in the environment (React)

Once the frontend container is running, the app will be updated each time a file is modified and saved. There is no need to relaunch the containers unless you add a new dependency.

React development server is accessible on `http://localhost:3000`.

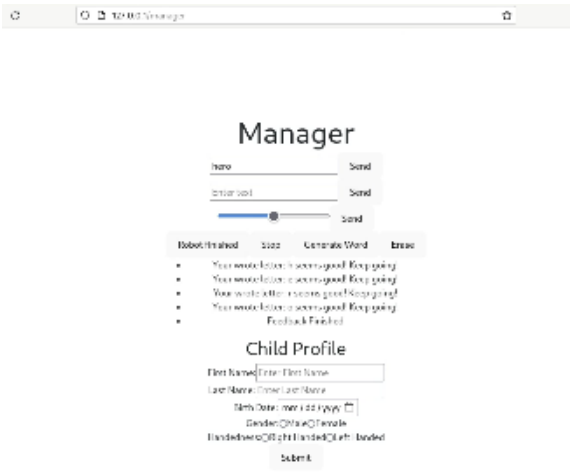
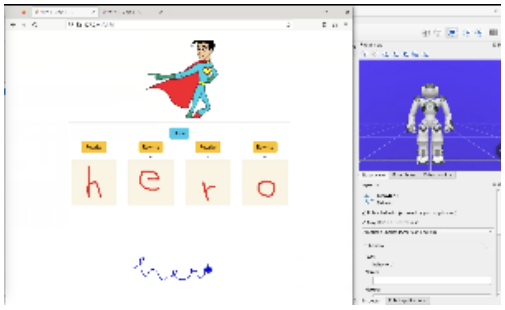
Acceptance Tests

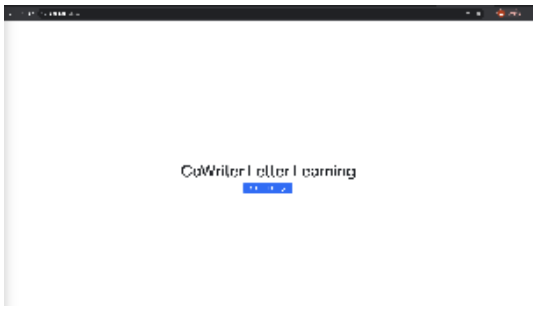
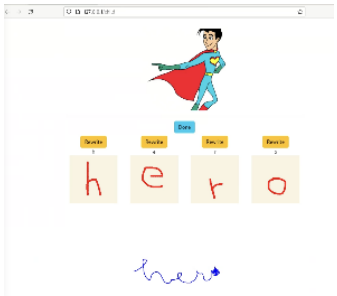
Prerequisites

Acceptance Criteria ID	Prerequisites ID	Specification	Result	Evidence
AC01	CS1	All three projects should be able to run under one unified environment and have no compatibility issues between each chunk of code	Pass	We created 2 Dockerfiles, one for the frontend (React web application), one for the backend (Flask API and ROS2 nodes). These Dockerfiles regroup all the installation commands required to build the project's environment. The source code can be compiled and ran without errors using a single Docker command. **refer**: | Development
AC02	CS2	All three projects should be merged into a single repository with features integrated	Pass	Our GitHub repository hosts the assembled code chunks taken from each previous project, as well as the new features implemented this semester. **refer**: Github repository
AC03	CS3	All the merging and integration process should be documented in a structured and organised way	Pass	We documented how to launch the project for both development and production environment on Confluence and in the README files of the GitHub repository. **refer**: Github repository, | Development and | Deployment

User Stories

Acceptance Criteria ID	User Story ID	User Story			Result	Evidence
AC04	US1	As a parent,	I want the robot to have a conversation with my kids in a child-friendly and safe manner	so that my child's interaction stays positive and free from inappropriate content.	Pass	When the robot hears child unfriendly sentences, he will redirect the conversation and ask the child about his interests. Tester: "You are stupid" Robot: "Sorry, but I can't assist with that. Why don't you tell me about your favourite animal?
AC05	US2	As a child,	I want the robot to associate a human gesture to its conversation	so that I would feel like talking to a real person.	Pass	When the robot is talking, a pre-recorded gesture will be chosen accordingly.

AC06	US3	As a parent,	I want my kids to be able to practice their struggling letters	so that the learning process can be more engaging.	Pass	After child writing the word, the algorithm will analyse the child handwriting and send the result to the manager UI. So that the manger can know which wiring letter is bad and exercise the child with the new word which contains that letter. On this example, the feedback received for the word "hero": 
AC07	US4	As a parent,	I want to add more child-friendly elements to UI such as illustrations	so it helps kids to easily understand and remember the words	Pass	Each time the teacher will submit a word, an AI image will be generated and printed on the child's UI. For example, the image generated for the word "hero": 

AC08	US5	As a researcher,	I want to move the UI from PyQT to a web version (browser)	so that I can access via various platforms and devices without the need for download /installation	Pass	When the researcher enter the localhost URL, he can access to the platform to choose the "child" and "manager" web to view. Both UIs are hosted on the same URL (2 buttons allow to access either the manager or the child)  UI for the manager:  UI for the child: 
AC09	US6	As a child,	I want to be able to select the domain I'm interested in	so that the learning becomes more fun and engaging	Pass	The robot will learn about the child's interest through the conversation. Then, using the "Generate Word" button located on the manager's UI, a word will be generated accordingly. Test case: (same as the demo video) Robot: "What are you interested in today ?" Tester: "I really like superhero movies" ... The word "hero" will be generated when the button is clicked.

| Deployment

This section gathers all the installations and commands needed to deploy and launch the project. Hence, the pages must be consulted in the same order as they appear in Confluence's tree structure:

- Ubuntu
- Choregraphe
- Docker
- Third-party API keys

to finally be able to run all the commands of Launch the Project.

Installations Required

Choregraphe

In order to communicate with the NAO robot, a software called Choregraphe has to be installed. It has two purposes:

- launch a robot simulation, to run code even if the physical robot is not available
- establish the communication with a real Nao robot.

Even if the installation page of Choregraphe offers installation files for Windows, Mac and Linux, but we recommend to use the Linux version.

Installation on Ubuntu

1. Download the setup file from this link.

2. Change the file permissions and execute it:

```
chmod +x choregraphe-suite-2.8.6.23-linux64-setup.run
sudo ./choregraphe-suite-2.8.6.23-linux64-setup.run
```

3. Try to run:

```
"/opt/Softbank Robotics/Choregraphe Suite 2.8/bin/choregraphe_launcher"
```

4. In case of an error:

```
# error
/opt/Softbank Robotics/Choregraphe Suite 2.8/bin/../lib/../lib/../lib/libz.so.1:
version `ZLIB_1.2.9' not found (required by /usr/lib/x86_64-linux-gnu/libpng16.so.16)
```

Run the following commands:

```
cd "/opt/Softbank Robotics/Choregraphe Suite 2.8/lib/"
sudo mv libz.so.1 libz.so.1.old
sudo ln -s /lib/x86_64-linux-gnu/libz.so.1
```

5. Command specified in 3 should work, it will launch the application. It is also possible to launch Choregraphe by clicking directly on the application shortcut.

(Adapted from this tutorial)

Docker

To install Docker, run the following instructions in your Ubuntu instance.

1. Uninstall all conflicting packages

```
for pkg in docker.io docker-doc docker-compose podman-docker containerd runc; do sudo apt-get remove $pkg; done
```

2. Add Docker's repository to your Apt repository

```
# Add Docker's official GPG key:
sudo apt-get update
sudo apt-get install ca-certificates curl gnupg
sudo install -m 0755 -d /etc/apt/keyrings
curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo gpg --dearmor -o /etc/apt/keyrings/docker.gpg
sudo chmod a+r /etc/apt/keyrings/docker.gpg

# Add the repository to Apt sources:
echo \
  "deb [arch="$(dpkg --print-architecture)" signed-by=/etc/apt/keyrings/docker.gpg] https://download.docker.com
/linux/ubuntu \
  "$(. /etc/os-release && echo "$VERSION_CODENAME")" stable" | \
  sudo tee /etc/apt/sources.list.d/docker.list > /dev/null
sudo apt-get update
```

3. Install Docker packages

```
sudo apt-get install docker-ce docker-ce-cli containerd.io docker-buildx-plugin docker-compose-plugin
```

4. Check if the installation is successful

```
sudo docker run hello-world
```

(Docker's installation guide for Linux is available here)

Post installation steps

After installing Docker, we recommend to execute the following commands:

```
sudo groupadd docker
sudo usermod -aG docker $USER
```

This will enable the current user to use Docker commands without calling `sudo` . To be effective, the user should restart his Ubuntu instance first.

In case the following error appears when executing a Docker command,

```
Cannot connect to the Docker daemon at unix:///var/run/docker.sock. Is the docker daemon running?.
See 'docker run --help'.
```

it means that Docker is not running. The service has to be started manually:

```
sudo systemctl start docker
```

NAO Robot

Connect the robot to the Wifi:

1. Make sure the router located in the lab is on and connected to an Ethernet plug, and that your computer is connected to that same network
2. Remove the hatch from the robot's head (at the back) and plug an ethernet cable
3. Press the "Nao" button located on the robot's chest. He will tell his current IP address (note it)
4. Navigate to that IP address on your browser. The credentials are the default ones username: nao, password: nao
5. Navigate to the wifi settings page and connect the robot to the network

Now that the robot is connected to the router network, open Choregraphe and establish the connection with the robot.

For more information, visit these two pages: Connect Nao to the Wifi and Access Nao Webpage.

Ubuntu

To run the software that enable communication with the NAO robot (Choregraphe), developers need to install a version of Ubuntu (20.04 or 22.04) on their laptop.

For Windows users

A dual boot (complete installation of the Linux OS) might be the best option because virtual machines can be really slow, in particular when Choregraphe is running.

For Mac users

First determine the computer's architecture by running the `uname -a` command in a terminal. Now there are two options:

- if the architecture is amd64 / x86 (mostly old models of Macs), then it is compatible with Chroregraphe's required architecture. You should be able to install the desired version of Ubuntu using BootCamp
- if the architecture is arm64 (new versions of Macs, using M1 or M2 chips), then it is not compatible with the required architecture.

Solutions for arm64 based Macs:

- VirtualBox, Parallels ... do not offer the possibility to emulate an amd64 architecture on arm64 based Macs, UTM does. But when Choregraphe and the programs are running, the virtual machine becomes really slow and laggy
- We also tried to only run Choregraphe in UTM and the code on the host. Choregraphe's robot port can be forwarded to the host and Docker Desktop offers the possibility to run amd64 based containers on arm64 architecture, but we never succeeded to reach that exposed port from the code running in a container
- Finally, we also considered to use GoogleCloudPlatform to host the amd64 based VM (tutorial here): by selecting the right amount of CPUs (at least 4), the result was more smooth compared to UTM. The only downside hosting the development environment on GCP is that we cannot connect to the real robot, the IP is unreachable from the VM. Moreover, running the VM generate costs (but usually, GCP offers some free credits to their new users that are sufficient to cover these costs).

In the end, UTM seems to be the unique viable solution if the tests have to be run with the real robot. If the simulated robot is enough, running the code on a GCP VM is a better (but costly) option.

If the developer only requires to do some code development or debugging that does not require any interaction with the robot (real or simulated), using Docker containers as a development environment can be enough (view | Tools).

Third-party API keys

Before launch the project, the following API keys and credentials are needed:

- OpenAI API
- Rapid API
- Google Application Credentials

1. Prepare the API keys and credentials.

2. Move the Google Application Credential json file into credential folder.

```
# Workdir in NA-Redback
mv *.json ./credentials/
```

3. Copy the .env.example file and rename to .env.

```
# Workdir in NA-Redback
cp .env.example .env
```

3. Fill in the OpenAI API key and Rapid API key.

4. Change <filename> to the credential filename.

```
export OPENAI_API_KEY=sk-...
export RAPIDAPI_KEY=...
export GOOGLE_APPLICATION_CREDENTIALS=/home/nao/credentials/<filename>.json
export NAO_IP=...
export NAO_PORT=9559
export SILENT_THRESHOLD=... # specify a value to setup the silence threshold for the microphone
```

Note:

- if you are using the virtual robot on Choregraphe, the IP address is 127.0.0.1
- If you are using the real robot, click on the robot's chest button, it will speak and tell its current IP address on the network it is connected to.

Launch the Project

Requirements: Ubuntu with Docker and Choregraphe installed and API keys are prepared

This section presents the steps required to launch the project in a production environment (final product). To launch a development environment see | Testing.

To launch the project, run the following commands in the same order they appear:

1. Clone the repository:

```
git clone git@github.com:COMP90082-2023-SM2/NA-Redback.git
cd NA-Redback
```

2. Check if the "make" command is available by running:

```
which make
# if the output is "/usr/bin/make", then skip the following commands
# if not, run
sudo apt-get update
sudo apt-get install -y make
```

3. Set the `ENV` variable to "production":

```
export ENV=production
```

4. Build the Docker images:

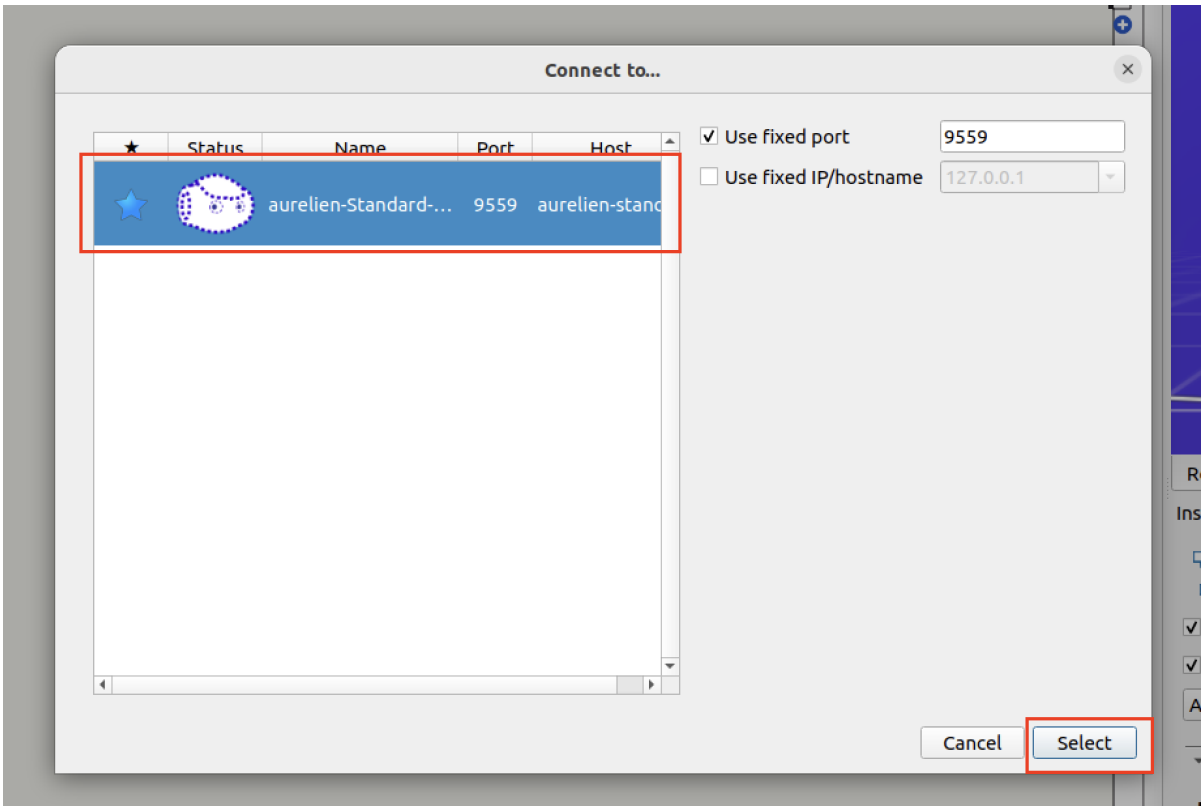
```
make compose-build
```

Note: once the images are built, you do not need to execute this step again unless you modify the environment (ex: installation of a new Python module) or the source code (new commit).

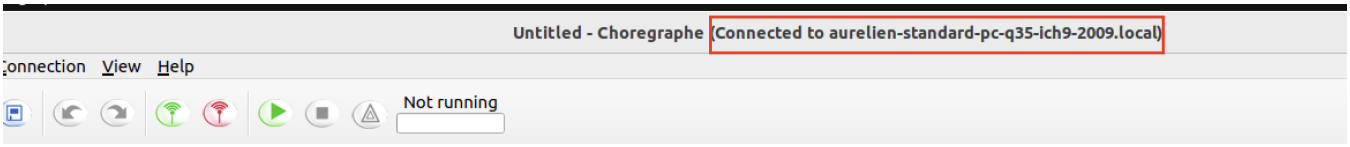
5. Launch Choregraphe and start the virtual robot:

Once Choregraphe is opened, click on Connection > Connect to...

Select the robot by clinking on it, then press Select.



After the initialisation, you should be able to see a similar message as the one below, meaning that the virtual robot is ready to be used.



6. Launch the Docker containers:

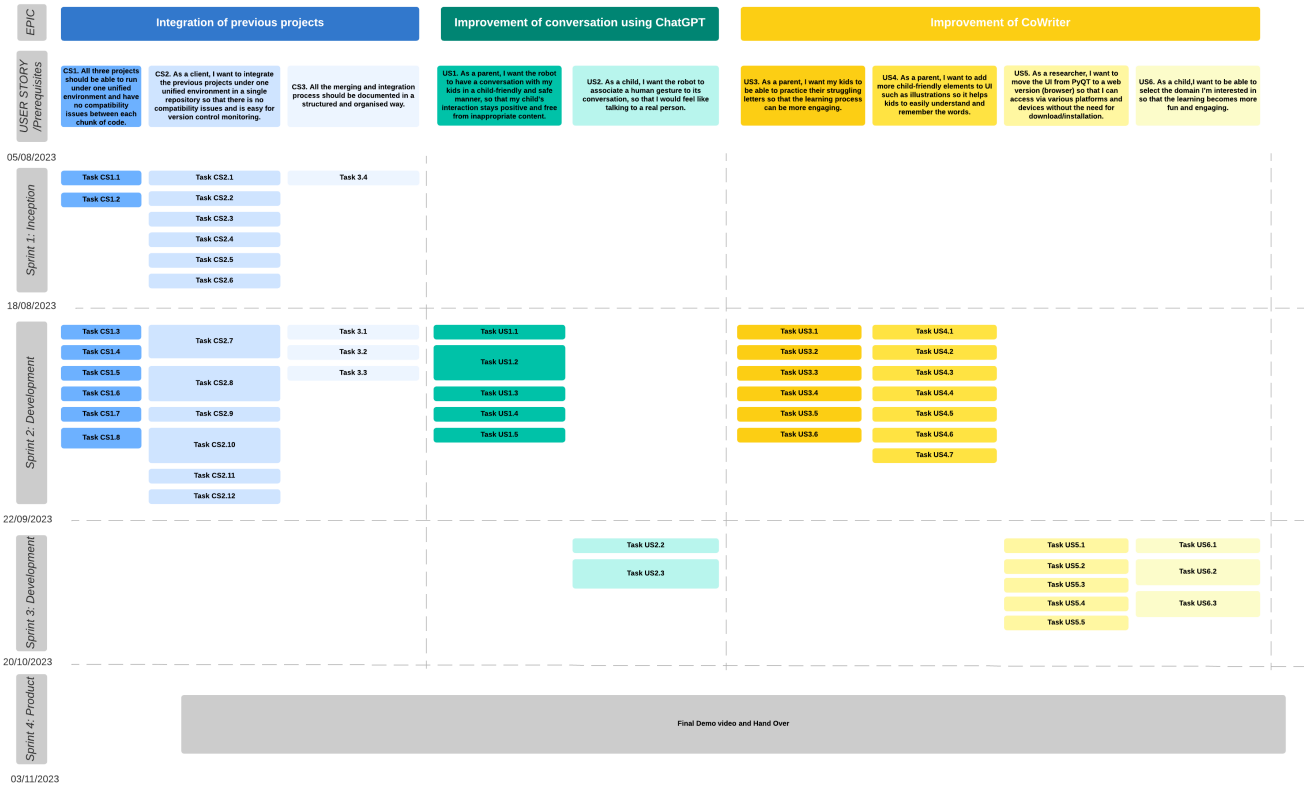
```
make compose-up
```

That command will start the fronted application (React), the ROS nodes and the Flask API (link between React and ROS).

Open your browser and navigate to the following URL to access the React application: `http://127.0.0.1`

| Sprint Ceremonies

| Sprint Planning



1. Task with larger square box means it has more points.
2. We still have problems with some user stories, so some of them won't have too much. We will update it after the next meeting with client.

Trello : https://trello.com/invite/b/CPdSWap5/ATTIdcb481b112c05c9eb2833be7521b972a4EC07C65/comp90082-2023-sm2-na-redback

Sprint1: Inception Planning

Sprint 1 Goal

For Sprint 1, our primary objective is to lay a solid foundation for the upcoming project by initiating productive interactions with our clients and comprehensively understanding their requirements. This involves engaging in an initial meeting with our clients to establish a clear scope and user stories for the project. The user stories and tasks should be arranged and distributed into sprints. In addition, we will delve into the past projects executed by our fellow teams to gain valuable insights and enhance our understanding of best practices.

Key Milestone

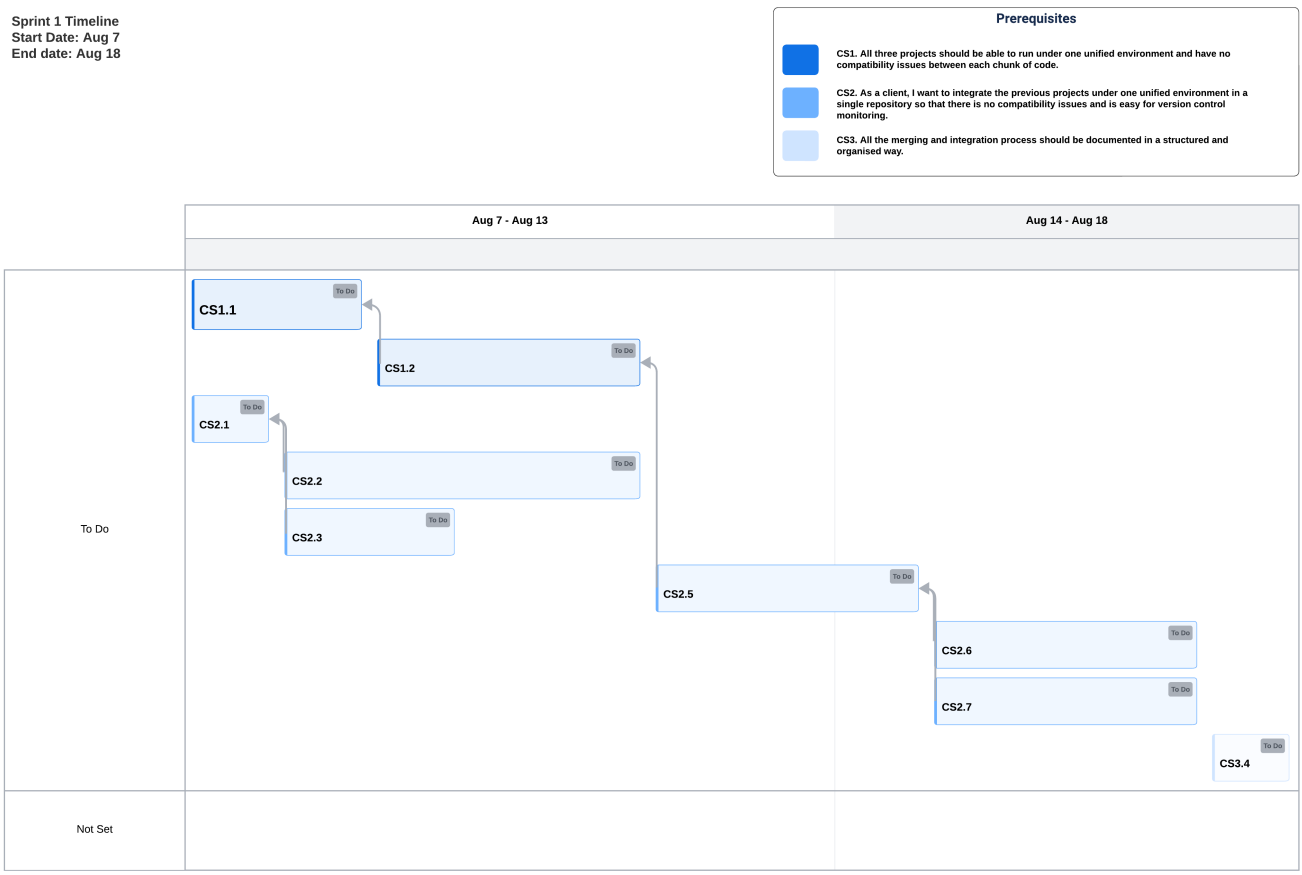
1. **Client Interaction:** Arrange and conduct an initial meeting with the clients. During this session, our aim is to establish rapport, communicate our team's expertise, and create an environment conducive to open dialogue. This interaction will also serve as an opportunity to gather preliminary information regarding the project's objectives, desired outcomes, and any specific requirements or constraints.
2. **Requirements Identification:** Thoroughly document all the insights obtained from the client interaction. Extract and clarify the project's core requirements, functionalities, and potential challenges. Ensure that all stakeholders are on the same page regarding the project's scope and expectations.
3. **Project History Review:** Examine the previous projects undertaken by other teams within the organization. This review will provide valuable context, highlighting successful strategies, potential pitfalls, and opportunities for innovation. By understanding the evolution of similar projects, we can leverage lessons learned and align our approach accordingly.
4. **Resource Preparation:** Compile and organize the necessary resources for the project. This includes refining our understanding of the technologies, tools, and methodologies that will be employed. By familiarizing ourselves with the project's technical landscape, we can streamline our execution and minimize potential roadblocks.

Prerequisites

Note that "Estimated Workload" indicate the estimation for this sprint and does not necessarily indicate the entire story points for the given user story. For the continuing requirements and user stories, partial story points will be allocated for each sprint. "Estimated Story Points Left" is the estimated amount of the total story points left for this user story after this sprint.

Requirement	ID	Specification	Priority	Total User Stories Points	Estimated Workload in this sprint	Estimated Story Points Left
Integration of previous projects	CS1	All three projects should be able to run under one unified environment and have no compatibility issues between each chunk of code	Must	47	10	37
	CS2	All three projects should be merged into a single repository with features integrated	Must	72	12	60
	CS3	All the merging and integration process should be documented in a structured and organised way	Must	7	1	6
					Total: 23	

Sprint 1 Timeline



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Expected Outcomes

By the end of Sprint 1, we aim to have a comprehensive understanding of the project's requirements, a clear overview of the client's expectations, and insights from previous projects that will guide our decision-making. This holistic preparation will set the stage for successful project execution in the upcoming sprints, ensuring that our team is well-equipped to deliver a solution that aligns with the client's needs and industry best practices.

- [x] Background description
- [x] DO-BE-FEEL list
- [x] GOAL MODEL
- [x] Personas
- [x] User Stories
- [x] Trello
- [x] Development Environment
- [x] Setting Github
- [x] Plan diagram

Trello : https://trello.com/invite/b/CPdSWap5/ATTIdcb481b112c05c9eb2833be7521b972a4EC07C65/comp90082-2023-sm2-na-redback

ChatGPT Generated: Yes

Assign the Story Points

Our team employs a collaborative and dynamic approach to project planning through the use of Planning Poker. We gather around and assign story points using the Fibonacci sequence – a unique method that encourages thoughtful estimation. Each team member contributes their individual perspective by selecting a number based on their assessment of the complexity involved. This sparks productive discussions, where we openly share insights, leading to a well-rounded understanding of the task at hand. Through this process, we collectively arrive at a consensus or average for the final story point assignment. This not only fosters team cohesion but also ensures a comprehensive evaluation of each task's intricacies, promoting accuracy and alignment in our project planning efforts.

One screenshot of how we giving storing points is shown as below.

Source from: https://planningpokeronline.com/

Sprint2: Development

Sprint Goal:

In Sprint 2, our focus is on conducting a comprehensive review and seamless integration of the three previous projects. We will also start working on adding features to the product under the integrated environment, while incorporating feedback received from the Sprint 1 submission. Despite not being part of the user stories, integration of previous projects in one unified environment is a primary goal for this project and is a complex, yet critical task in order to ensure the quality and completeness of the end product.

Sprint Backlog:

Note that "Estimated Workload" indicate the estimation for this sprint and does not necessarily indicate the entire story points for the given user story. For the continuing requirements and user stories, partial story points will be allocated for each sprint. "Estimated Story Points Left" is the estimated amount of the total story points left for this user story after this sprint.

Prerequisites:

Requirement	ID	Specification	Priority	Total User Stories Points	Estimated Workload in this sprint	Estimated Story Points Left
Integration of previous projects	CS1	All three projects should be able to run under one unified environment and have no compatibility issues between each chunk of code	Must	47	37	0
	CS2	All three projects should be merged into a single repository with features integrated	Must	72	60	0
	CS3	All the merging and integration process should be documented in a structured and organised way	Must	7	6	0
					Total: 103	

User Stories:

Epic	ID	User Story			Priority	Total User Stories Points	Estimated Workload in this sprint	Estimated Story Points Left
Improvement of conversation using ChatGPT	US1	As a parent,	I want the robot to have a conversation with my kids in a child-friendly and safe manner	so that my child's interaction stays positive and free from inappropriate content.	Must	29	29	0
Improvement of CoWriter	US3	As a parent,	I want my kids to be able to practice their struggling letters	so that the learning process can be more engaging.	Must	30	30	0
	US4	As a parent,	I want to add more child-friendly elements to UI such as illustrations	so it helps kids to easily understand and remember the words	Could	34	34	0
							Total: 93	

Sprint2 Timeline

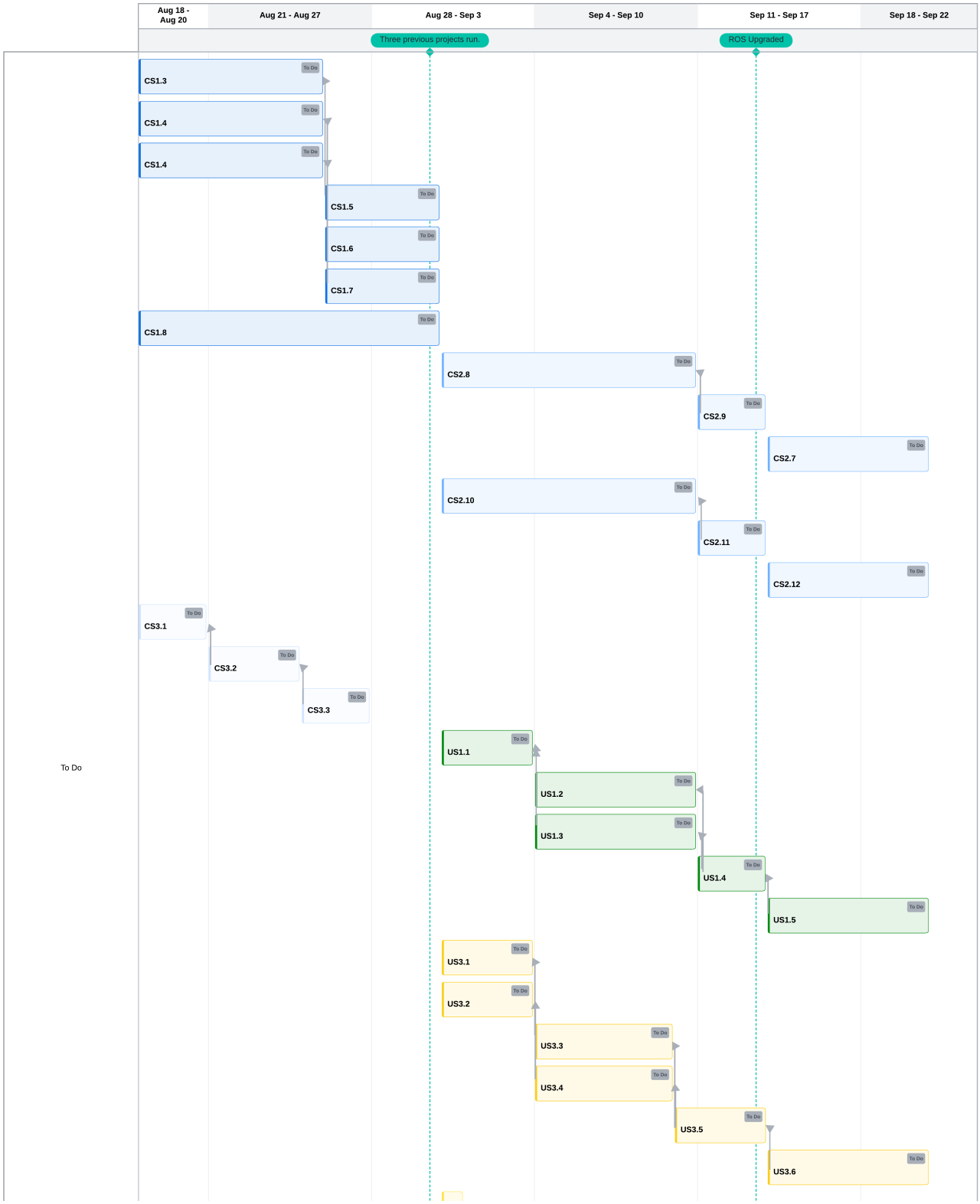
Sprint 2 Timeline
Start Date: Aug 19
End date: Sep 21

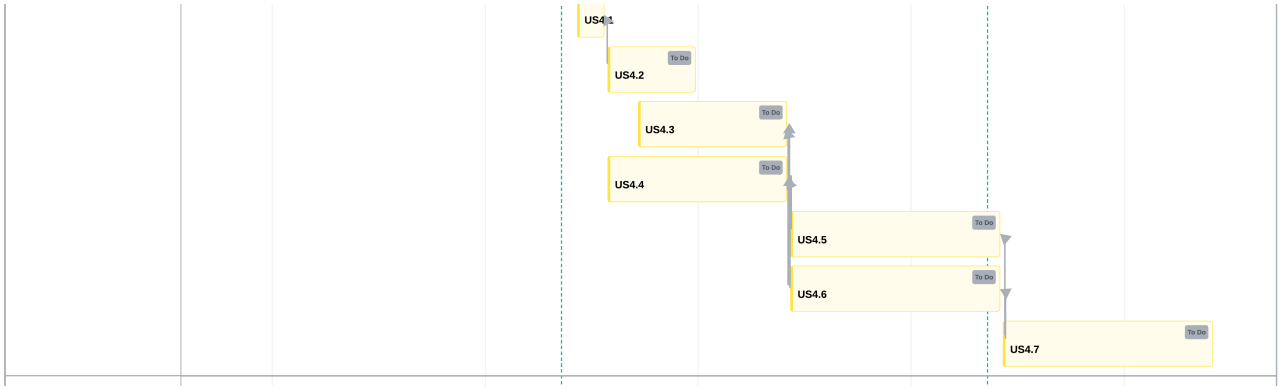
Prerequisites

- **CS1.** All three projects should be able to run under one unified environment and have no compatibility issues between each chunk of code.
- **CS2.** As a client, I want to integrate the previous projects under one unified environment in a single repository so that there is no compatibility issues and is easy for version control monitoring.
- **CS3.** All the merging and integration process should be documented in a structured and organised way.

User Stories

- **US1.** As a parent, I want the robot to have a conversation with my kids in a child-friendly and safe manner, so that my child's interaction stays positive and free from inappropriate content.
- **US3.** As a parent, I want my kids to be able to practice their struggling letters so that the learning process can be more engaging.
- **US4.** As a parent, I want to add more child-friendly elements to UI such as illustrations so it helps kids to easily understand and remember the words.





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Expected Outcomes

By the end of Sprint 2, we aim to integrate the previous projects together successfully under one unified environment and implement improved features to the product.

- [x] Previous projects are merged together in one unified environment
- [x] The code after integration can run smoothly on our environment
- [x] Measures have been applied to ensure the kids-friendly and safe conversation between robot and children
- [x] An algorithm to detect struggling letters have been implemented
- [x] AI-generated illustrations have been added to the UI

Sprint3: Development

Sprint Goal:

In this sprint, our primary goal is to complete the continuing tasks from Sprint 2 as well as to work on 5 user stories as outlined below:

1.Continuing tasks from Sprint 2

- Prerequisites: Integration of previous projects
  - Merge Bluering and Boxjelly with Redback under ROS2 env
- US3: Finish integration of the struggling-letter algorithm

2.Implement more enhanced features to the product

- US2: Add gestures/motions to robot using ChatGPT
- US5: Move UI to a web version
- US6: Enhance a selection of words in line with a child's interest

Sprint Backlog:

Note that "Estimated Workload" indicate the estimation for this sprint and does not necessarily indicate the entire story points for the given user story. For the continuing requirements and user stories, partial story points will be allocated for each sprint. "Estimated Story Points Left" is the estimated amount of the total story points left for this user story after this sprint.

1. Continuing tasks from Sprint 2

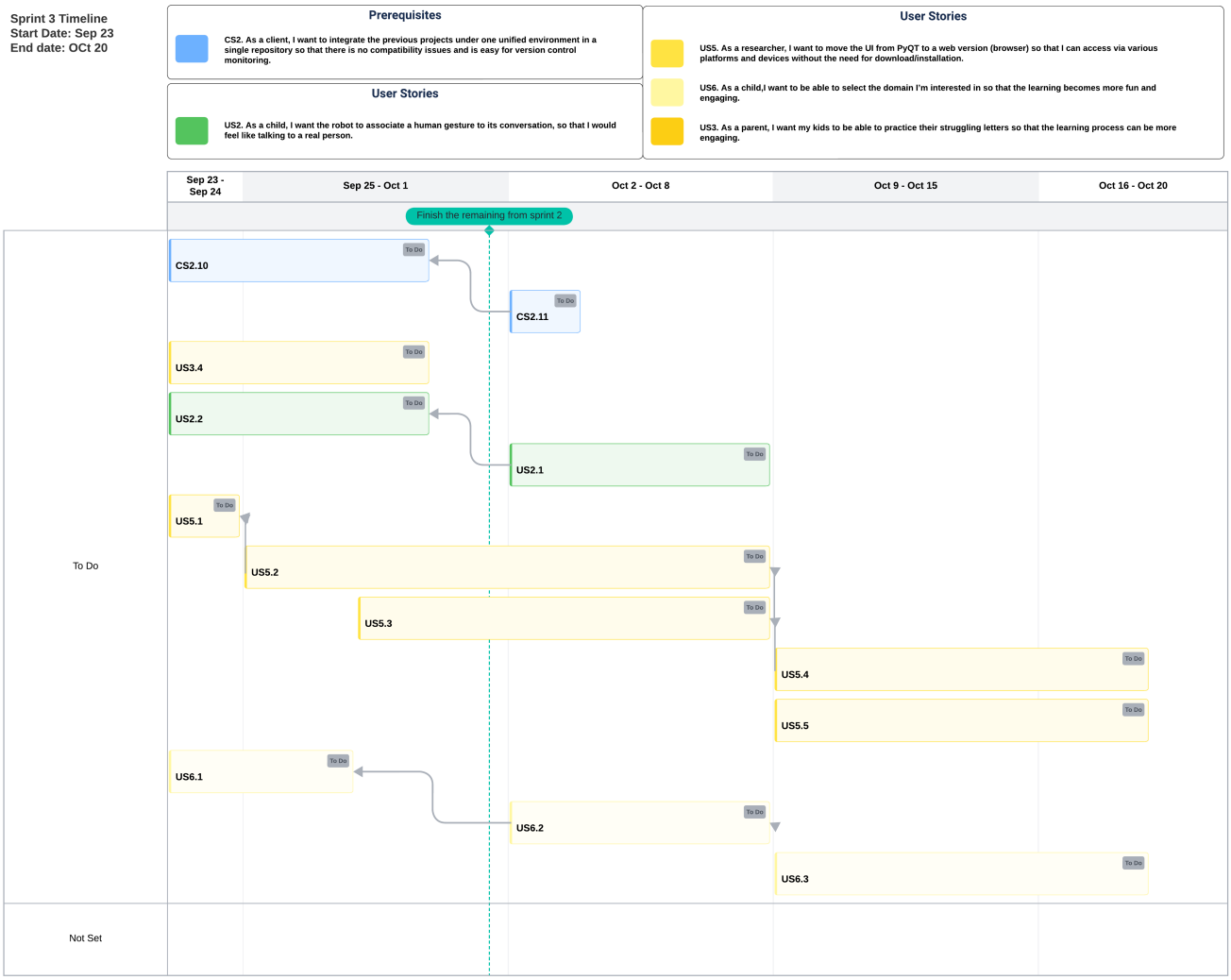
Requirement	ID	Specification	Priority	Total User Stories Points	Estimated Workload in this sprint	Estimated Story Points Left
Integration of previous projects	CS2	All three projects should be merged into a single repository with features integrated	Must	72	22	0
					Total: 22	0

Epic	ID	User Story			Priority	Total User Stories Points	Estimated Workload in this sprint	Estimated Story Points Left
Improvement of CoWriter	US3	As a parent,	I want my kids to be able to practice their struggling letters	so that the learning process can be more engaging.	Must	30	8	0
							Total: 8	0

2. User stories to complete

Epic	ID	User Story			Priority	Total User Stories Points	Estimated Workload in this sprint	Estimated Story Points Left
Improvement of conversation using ChatGPT	US2	As a child,	I want the robot to associate a human gesture to its conversation,	so that I would feel like talking to a real person	Could	21	21	0
Improvement of CoWriter	US5	As a researcher,	I want to move the UI from PyQT to a web version (browser)	so that I can access via various platforms and devices without the need for download/installation	Should	35	35	0
	US6	As a child,	I want to be able to select the domain I'm interested in	so that the learning becomes more fun and engaging	Could	34	34	0
							Total: 60	

Sprint 3 Timeline



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Expected Outcomes

By the end of Sprint 3, we aim to finish integrating the previous projects under a single repository and implement improved features to the product.

- [x] All three previous projects are integrated together and can run under one unified environment
- [x] The struggling-letter algorithm is further refined using trajectory instead of output and is successfully integrated
- [x] NAO can make a variety of gestures/motion
- [x] UI has been migrated to a web version
- [x] NAO can suggest a selection of words in line with a child's interest

Sprint4: Product

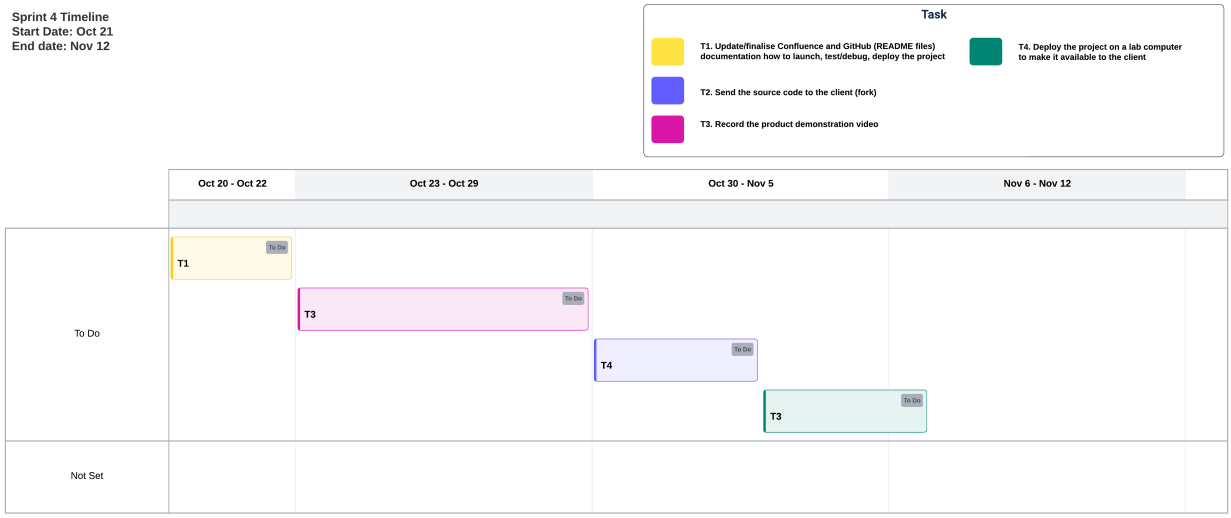
Sprint Goal:

For this sprint, we are aiming to complete the handover process and take the final product video.

Sprint Backlog:

Task ID	Task	Priority	Estimated Workload
T1	Update/finalise Confluence and GitHub (README files) documentation how to launch, test/debug, deploy the project	Must	8
T2	Send the source code to the client (fork)	Must	1
T3	Record the product demonstration video	Must	5
T4	Deploy the project on a lab computer to make it available to the client	Must	3
			Total:17

Sprint 4 Timeline



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Expected Outcomes

By the end of Sprint 4, we aim to hand the project to the clients completely as required by the client. The whole project should be easy for the following team in later semester.

- [x] Update/finalise Confluence and GitHub (README files) documentation how to launch, test/debug, deploy the project
- [x] Send the source code to the client (fork)
- [x] Record the product demonstration video
- [x] Deploy the project on a lab computer to make it available to the client

| Sprint Review

Sprint 1 Review

Sprint 1 review meeting was held on 25 August between the client and dev team. The main agendas were to review the project scope, out-of-scope, and requirements (user stories) and to brief on the Sprint 2 plan. Overall, the client was happy with the current direction where the team is going and provided some tipes and recommendations on implementing features for the next sprint.

Details on the discussion can be found below:

Discussion Item	Client Feedback
Scope	Client agrees with the current scope outlined
Requirements	Client agrees with the current requirements
Sprint 2 plan	• For US3, useful library called "fastdtw" can be used to compute the distance ◦ way to measure how good of a child writing is based on the comparison between hand-writing and template (we should set a threshold for improving) • For US4, the illustration can be generated form AI
Questions & Feedback	• For US6, robot could suggest child to move to a domain that it think might be interesting for the child based on their conversation
Remarks from client	• Should be careful with the versions of previous projects since their environmentes may vary • Conduct the lab induction and test on NAO robot • The team is currently on the right direction with the project

The Sprint 1 meeting minutes and record can be found **HERE**.

Sprint 2 Review

Sprint 2 review meeting was held on 21 September between the client and dev team. The main agendas were to **1) review the Sprint 2 achivement and demo video, 2) share the Sprint 3 plan**, and lastly **3) clarify user stories related to ROSbag data annotation** which the team will be working on the next sprint. Implementation of the Sprint 2 dev tasks and features has been documented in details in the Development Features page.

Overall, the client was satisfied with the team's achivement for this sprint and acknowledged the technical challenges of integrating previous projects.

Details on the discussion can be found below:

Discussion Item	Client Feedback
Sprint 2 demo video	Client is satisfied with the progress the team has made in this sprint and acknowledged the technical difficulties and complications involved with integration Few tips on improving US3 ◦ try to use trajectory instead of the ouptut ◦ can use "fastdtw" to measure distance ◦ setting a dynamic threshold is a tricky part
Sprint 3 plan	Client agrees with the plan proposed
Clarifying tasks related to ROSbag data annotation	Two main tasks: • logging information during the session with a kid (log activity, log video coming from the robot's camera, log audio which can be handled uner the bag of data timestamp) • annotating the ROSbag (build a system to detect failutre during interaction, tag event) ◦ can use an existing tool (https://github.com/chili-epfl/qml-rosbag-annotator) to log data from cowriter

The Sprint 2 meeting minutes and record can be found **HERE**.

Sprint 3 Review

Sprint 3 review meeting was held on 19 October between the client and dev team. The main agendas were to **1) review the Sprint 3 achivement and demo video, 2) share the Sprint 4 plan**, and lastly **3) clarify if the client has any specific request for preparing the handover**. Implementation of the Sprint 3 dev tasks and features has been documented in details in the Development Features page.

Overall, the client was sastisfied with the successful integration of previous projects as well as other features we implemented for this Sprint including added motions/gestures to the robot, personalised word generaton, UI migration to a web app.

Earlier this sprint, "Upgrade ROSbag data management" part was moved from in-scope to out-of-scope of the project due to time constraint. This was communicated and confirmed by the client.

Details on the discussion can be found below:

Discussion Item	Client Feedback
Description of features implemented in Sprint 3 & Review demo video	Client is happy about the results
Share Sprint 4 planning	Looks good, no comment
Any specific requests for handover?	1) Make sure the program can run in the lab computer so that next team can test /work on it 2) Send the source code to the client's repository (fork) ▪ team agrees

The Sprint 3 meeting minutes and record can be found **HERE**.

Sprint 4 Review

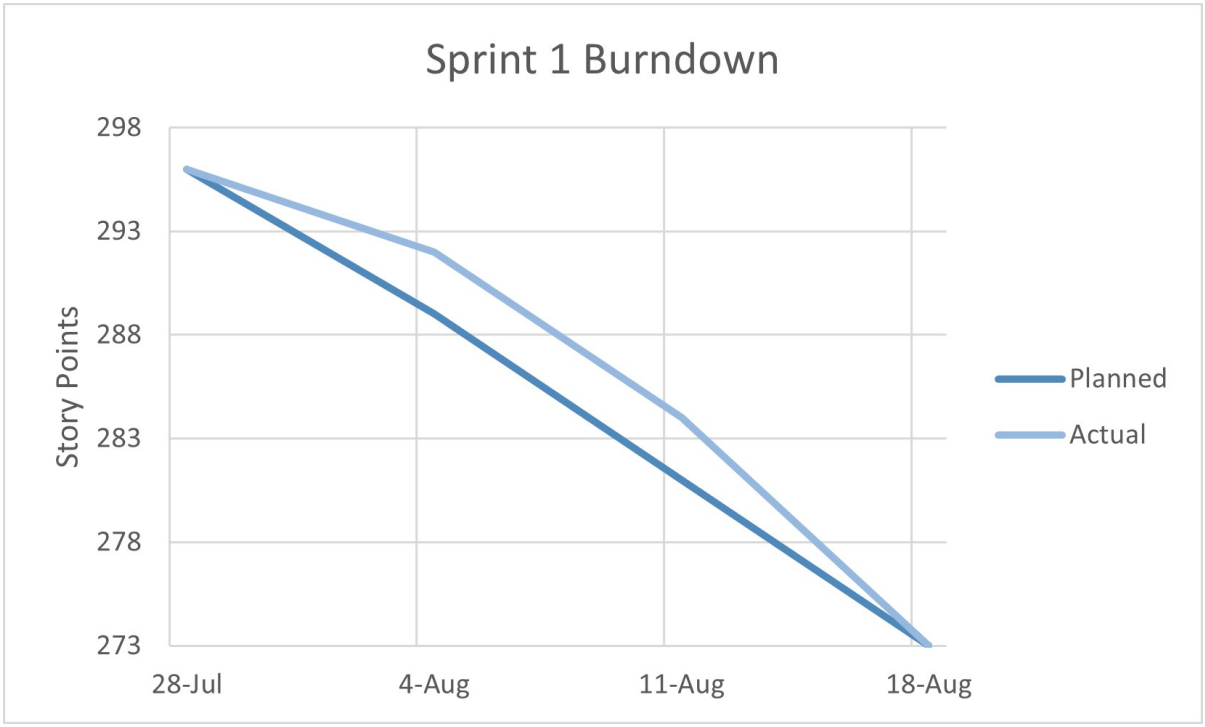
As no further development was executed during Sprint 4 and that all the necessary handover instruction and wrap up was communicated with the client during Sprint 3 review meeting, no additional review meeting for Sprint 4 was conducted.

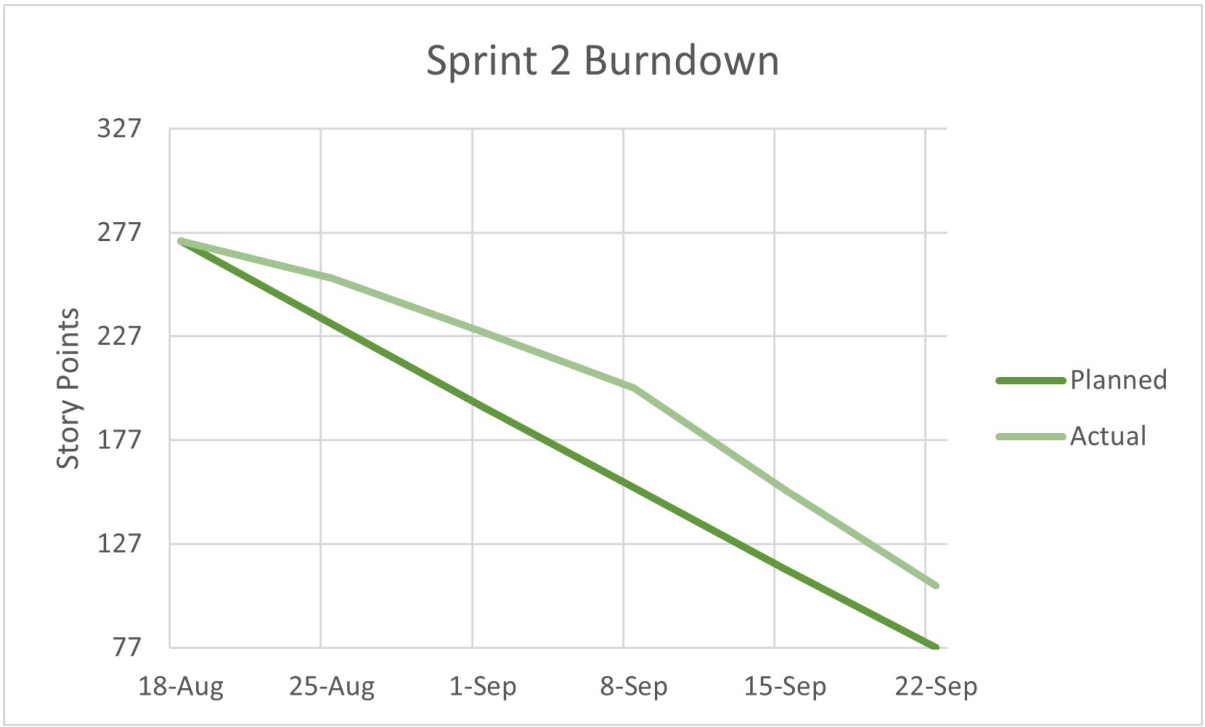
All expected outcome from Sprint 4 was fulfilled:

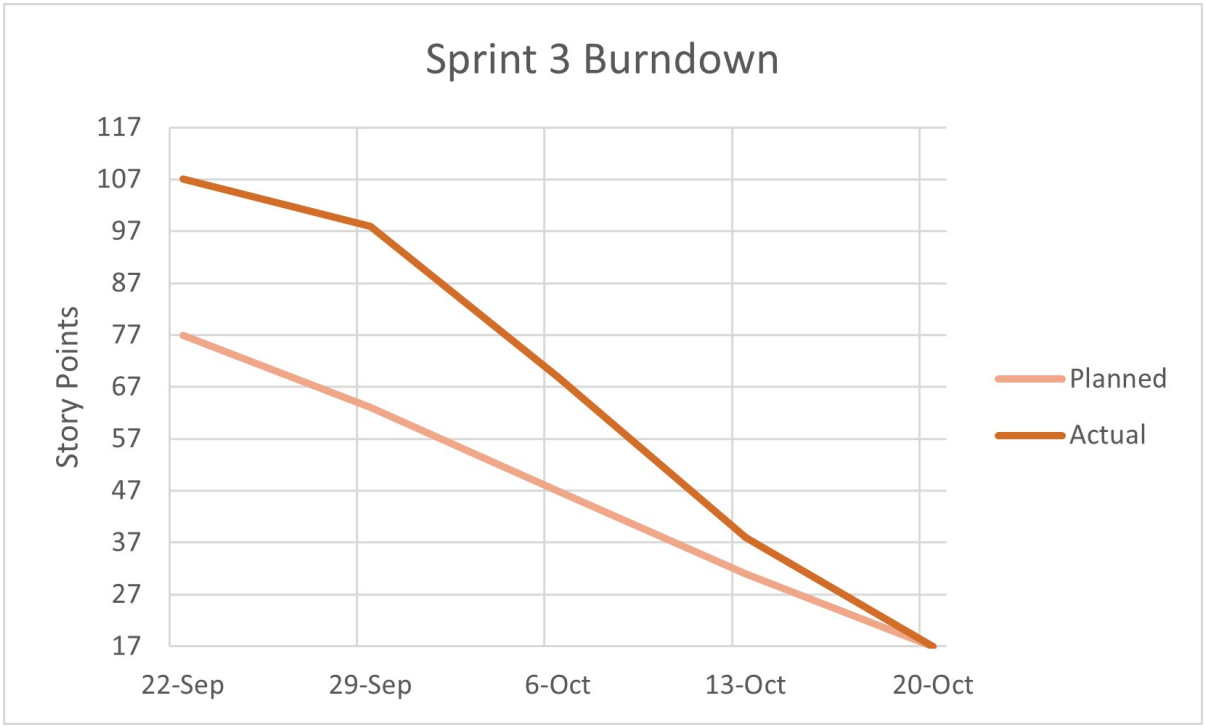
- [x] Update/finalise Confluence and GitHub (README files) documentation how to launch, test/debug, deploy the project
- [x] Send the source code to the client (fork)
- [x] Record the product demonstration video
- [x] Deploy the project on a lab computer to make it available to the client

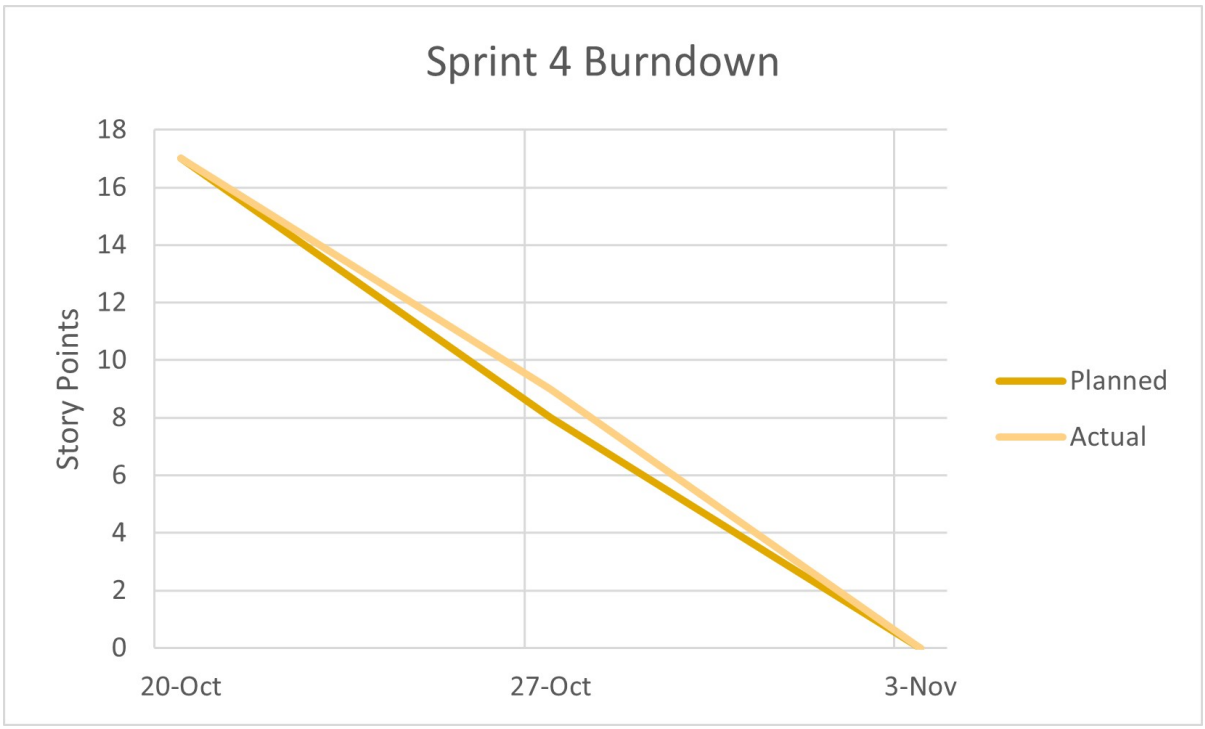
| Sprint Retrospective

Burndown Chart for each Sprint





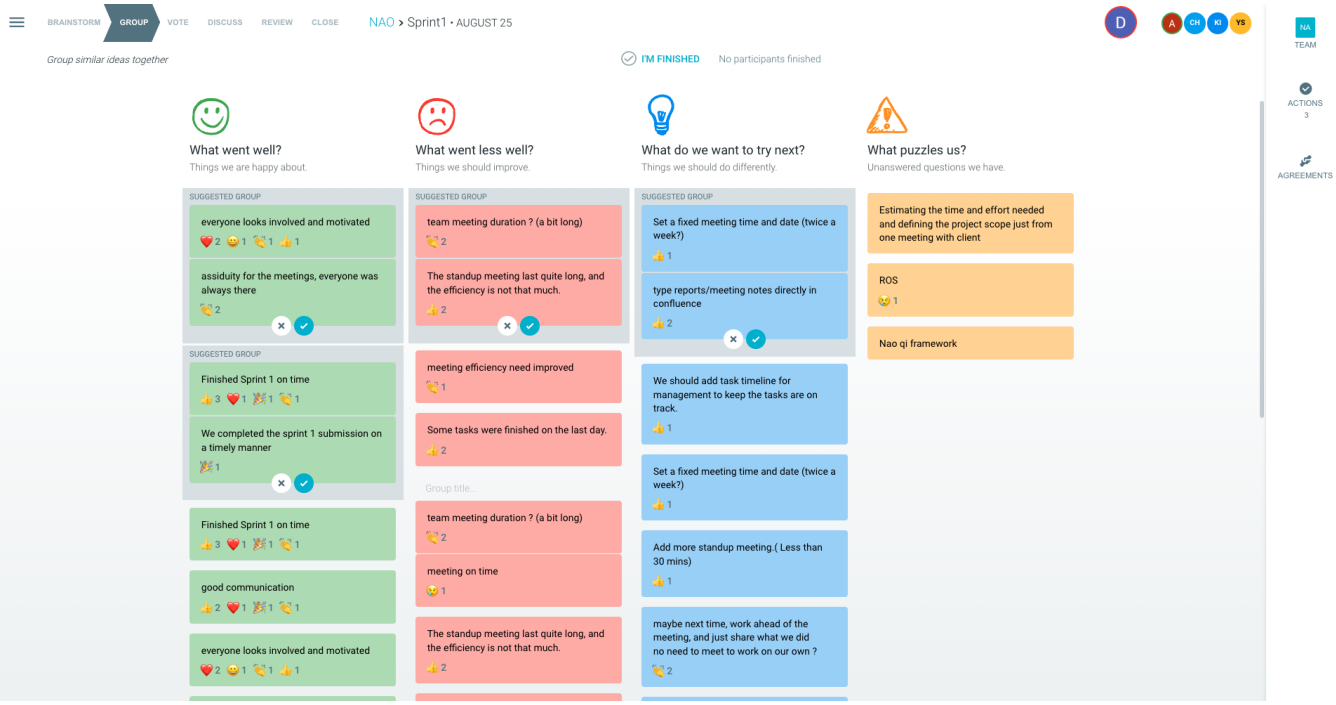

Sprint 3 Burndown
Story Points
117
107
97
87
77
67
57
47
37
27
17
22-Sep
29-Sep
6-Oct
13-Oct
20-Oct
Planned
Actual


Sprint 4 Burndown
Story Points
18
16
14
12
10
8
6
4
2
0
20-Oct
27-Oct
3-Nov
Planned
Actual

Sprint 1 Retrospective

Meeting Outcome

Our team relies on TeamRetro to conduct our agile retrospectives seamlessly. This powerful tool has transformed the way we reflect on our sprints, enabling us to collaboratively analyze our successes and areas for improvement. With it's anonymous interface, we can efficiently capture valuable feedback from every team member, ensuring that our retrospectives are not only productive but also engaging. The screenshoot is shown below.



Link: https://www.teamretro.com/

From the feedback given by our teams, it can be categorized into following aspects.

What went well?
Everyone get involved and motivated in Sprint 1.
Good communications between team members.
Finished Sprint 1 on time with a good quality.

What went less well?
The time for stand up meeting is quite long.
The meeting efficiency is not that high.
Haven't agreed on a time that works out for everyone. (No well scheduled meeting.)

What do we want to try next?
Set a fixed meeting duration and date.
Document everything in confluence.
Add task timeline for management to ensure the tasks are on track.
Add more stand up meeting.(At least twice a week)
Set agenda for each meeting to make it more efficient.

When reviewing the progress of the first sprint, everyone agree that they were get involved and motivated in Sprint 1. According to the Trello board, the total workloads for the first sprint were properly assigned. It also shows that each team member is fully contributing to the project. For each meeting in the first sprint, the meeting time was well controlled to provide functional outcomes for monitoring the quality of the project. However, most of us pointed out that the efficiency for the meeting is not high enough. Therefore, for our next sprint, we should definitely organize the meeting in a good manner to make it more efficient.

Overall, the first sprint went smoothly and successfully as planned.

Sprint 2 Retrospective

Meeting Outcome

Link: https://www.teamretro.com/

From the feedback given by our teams, it can be categorized into following aspects.

What went well?
Progress are documented in Confluence.
Meeting is well planned and managed.
Take the meeting as planned.
A excellent developing environment has been set up.

What went less well?
The progress of the project went slowly at the beginning.
Underestimated the workload for this sprint.
Unable to complete all the task for this sprint.

What do we want to try next?
Give order and timeline to the task. (Already been done)
Clearly distributed the task at the beginning of the sprint.
A proper estimate on workload for next sprint.

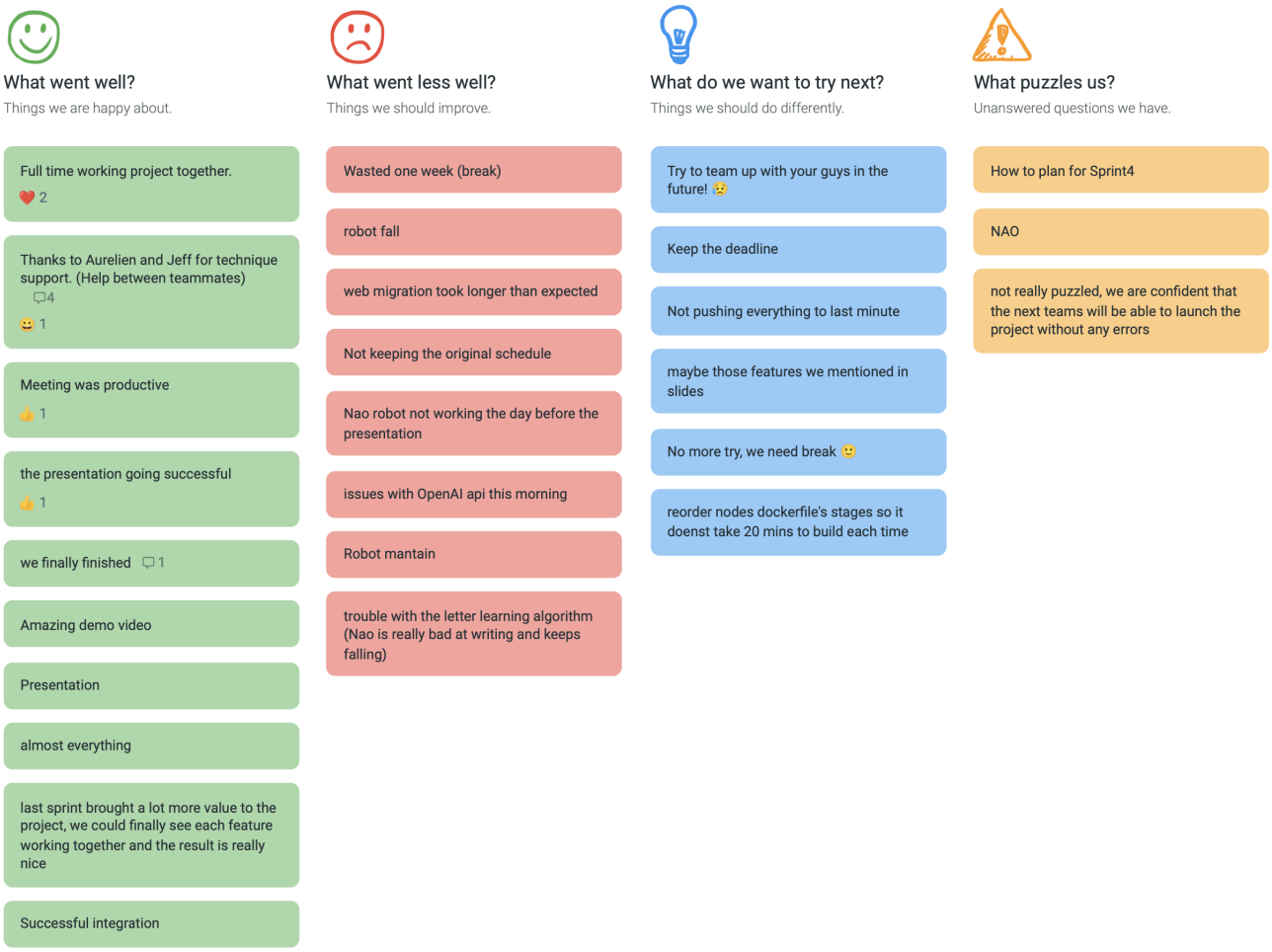
Task distribution is not clear at the beginning of the sprint.

After taking the sprint 1 retrospective, our team improved a lot in managing the meeting, which we performed less well in sprint 1. More meetings are held in sprint 2. However, the progress went slowly at the beginning of the sprint. Because most of our group members are inexperienced in handling real-world projects. It gets confused when setting tasks for user stories and distributing the tasks at the beginning. As it was the first time for us to engage in such a venture, there was a notable learning curve that needed to be navigated. Meanwhile, the lack of prior exposure results in overestimating the workload for some tasks. Even though we fixed the problem later and became more productive, our group was still unable to finish all the planned tasks on time.

Since now all of our group members are familiar with this project, a more clear distribution of the task will be given at the beginning of the next sprint. Meanwhile, a proper and reasonable estimate of workload will be given for the next sprint.

Sprint 3 Retrospective

Meeting Outcome



Link: https://www.teamretro.com/

From the feedback given by our teams, it can be categorized into following aspects.

What went well?
Progress are documented in Confluence.
The output of the agile process is good.
Meetings are productive.
Good cooperation.

What went less well?
Some tasks take longer than the plan.
Lack of risk control.
Late access to the robot due to maintenance.

What do we want to try next?
Push everything before the deadline.

Having completed both Sprint 1 and Sprint 2, our team has gained substantial expertise in the agile development process. The progress unfolded smoothly, aligning with our expectations. Nonetheless, there remains room for improvement, particularly in conducting a thorough risk analysis. In the course of Sprint 3, the robot required maintenance, leading to an unforeseen delay in our testing phase. Concurrently, the robot experienced recurring issues such as instances of falling and operational malfunctions. These challenges significantly impacted our progress and deployment efforts.

Additionally, we finished all the tasks in a good quality before the sprint 3 and have a great demonstration to the supervisors.

Sprint 4 Retrospective

Meeting Outcome

Link: https://www.teamretro.com/

From the feedback given by our teams, it can be categorized into following aspects.

What went well?
Deployment really easy
Great presentation video

What went less well?
Almost everything went really
We were a bit in a rush at the end of the sprint

This last sprint ends our project.

The containerisation of the source code eased a lot the deployment of the project on the lab's computer. Only a few adjustments were needed, like the adjustment of the computer's microphone threshold for the speech recognition.

Everything went well despite we were a bit in a rush during the last days of the sprint, especially for the client's feedback: we requested it a bit too late.

| Ethical Considerations

Intro

Due to the involvement of early childhood education in the project, addressing ethical issues is a critical task. This is to ensure that the design and execution of these product are carried out with extra care, prioritizing the well-being and development of children. Below are the key ethical factors that should be considered when creating and deploying a program that uses the NAO robot to teach children how to write letters, along with possible measures to take to minimise the impact.

Ethical Principles

1. Privacy and Data Security

Data Collection and Storage

- Ensure that any data collected during interactions with the NAO robot, such as handwriting samples, audio recordings, or visual data, is securely stored and anonymized to protect the children's privacy.
- Obtain informed consent from parents or legal guardians regarding data collection and storage.

Consent and Transparency

- Clearly communicate to parents, guardians, and educators the types of data collected, how it will be used, and for what purposes.
- Allow parents and guardians to opt-out of data collection and usage if they have concerns about their child's privacy.

2. Child Safety

Physical Safety

- Implement safety features to ensure that the NAO robot does not pose any physical harm or danger to children.
- Regularly test and maintain the robot to prevent any malfunction that could lead to accidents.

Emotional Safety

- Monitor children's emotional reactions to the robot's teaching methods and content to ensure they are not experiencing distress while doing the testing process.
- Provide stop mechanisms for children if they encounter emotional challenges during the learning process.

Educational Safety

- Ensure that the robot are using right, heathy, and constructive conversation with children.
- Ensure that the robot's interactions are age-appropriate and align with educational goals.
- Avoid using crude language and obscene words while communication.

3. Equity and Inclusivity

Access and Opportunity

- Ensure that the program is accessible to a diverse range of children, regardless of their socioeconomic status, abilities, or geographic location.
- Take steps to bridge the digital divide and provide equal access to educational opportunities.

Avoiding Bias

- Carefully curate and design content to avoid reinforcing stereotypes, biases, or discriminatory ideas.
- Monitor and correct any unintended biases that may emerge during the interaction between the robot and children.

4. Educational Efficacy

Pedagogical Effectiveness

- Continuously evaluate and improve the program's effectiveness in teaching letter writing, focusing on evidence-based pedagogical methods.
- Involved with educationalist to setup and improve the education process.
- Ensure reasonable and effective cyclic learning, such as review all struggled letters.

Transparent Evaluation

In this project, the feedback for child writing is viewable in Manager UI, so it keep Transparent Evaluation for all users, including kids, parents, and educators.

- Share evaluation results with parents, guardians, educators, and relevant stakeholders to maintain transparency and accountability in the program's educational outcomes.
- Provide parents and children with meaningful and helpful learning feedback.

Potential Ethical Problem

Creating a program that utilizes the NAO robot to teach children how to write letters must be done with a strong commitment to ethical considerations. We consider and conclude our current ethical consideration, but continuous monitoring, evaluation, and adaptation are key to upholding these ethical principles throughout the program's lifecycle. This means we will keep explore and consider the future potential ethical issues, and update this ethical part.

Ethical Issues Records

Ethical issues	Stage	How we solve it
Privacy and Data Security	Sprint 1	The child profile are stored in logs. In this case, we notice the importance of ensuring users' information while planning the project. To make users feel reliable to using this NAO, we provides a contract for users to promise the safety of their personal information.
Child Safety	Sprint 3	Physical Safety: While testing with the NAO robot, we find the robot sometimes make sudden and greater motion while writing letters. This might scared and hurt kids while learning. In this case, we make the pens tracks smoothly, so motion won't be sweeping. Emotional Safety: In this project, we keep the emotional safety for kids while communicating. Kids can stop the process by stating a desire to stop if they feel uncomfortable.
Child Safety	Sprint 2	In this project, we ensure the educational safety through filtering crude language and obscene words and use ChatGPT to ensure a health conversation.
Educational Efficacy	Sprint 1	In this project, we ensure the Pedagogical Effectiveness through providing iteration of handwriting process and allow kids to choose their own interesting topics. Beside, the in-time feedback for each letters, ensure kids can get improvements for each practice.

| Cyber Security Analysis

1. Data Privacy and Protection:

The system collects user data, especially from children, it must adhere to data privacy regulations. Ensure that sensitive data is properly encrypted and stored securely. When data is transferred between the robot, laptops, and servers, it should be encrypted to prevent interception by malicious actors.

In terms of the logging and annotation module, consider what data will be logged, where it will be stored, and who will have access to it. Ensure that any logs containing sensitive information are properly protected.

- **Potential Attacks**

  Data breaches, unauthorized access, eavesdropping.

- **Consequences:**

  Exposure of sensitive child and user data, legal and regulatory penalties, damage to reputation.

- **Possible Mitigations:**
  - Encrypt sensitive data both at rest and in transit.
  - Implement access controls and user authentication.
  - Regularly audit data access and usage.
  - Comply with data privacy regulations (e.g., GDPR, Privacy Act).
  - Limit data collection to what is necessary for the project's functionality.
- **Specific Actions:**
  - We limit the data collected from the children to only necessary information (name, birth date, handedness, gender). In addition, It is optional to provided any of these information.
  - Currently, our web app is only for user interface. It is hosted on the local network and the data will only be saved in client's laptop. Therefore, the possibility of sensitive data being exposed is low.

2. Child Safety:

Given that the project involves interactions with children, there's a responsibility to ensure that the system does not expose children to inappropriate content, including inappropriate responses from ChatGPT. When interacting with children, should be programmed to follow strict conversational guidelines to prevent any harmful or inappropriate content from being generated.

- **Potential Attacks:**

  Exposure to inappropriate content, harmful interactions.

- **Consequences:**

  Emotional harm to children, reputational damage.

- **Possible Mitigations:**
  - Implement content filtering and moderation for ChatGPT.
  - Supervise interactions with children.
  - Educate children and parents about responsible use.
- **Specific Actions:**
  - We implemented a filtering and moderation functionality to ensure the conversation is child-safe.
  - The project is designed to be use with a teacher's supervision. A child is not supposed to use it alone.

3. Web Security:

we are moving the UI to a web-based platform, so we need to ensure that the web application is designed with security best practices in mind. This includes protecting against common web vulnerabilities.

- **Potential Attacks:**

  Cross-site scripting (XSS), SQL injection, cross-site request forgery (CSRF), session hijacking.

- **Consequences:**

  Data theft, unauthorized actions, defacement of the web UI, loss of user trust.

- **Possible Mitigations:**
  - Use a secure web framework with built-in protections.
  - Implement input validation and output encoding.
  - Use HTTPS to encrypt data in transit.
  - Employ security headers (e.g., Content Security Policy) to mitigate XSS.
  - Regularly update web components and libraries.
- **Specific Actions:**

    - As mentioned above, the web app is hosted on local network and it is up only when starting the system. We decided that HTTPS is out-of-scope and use HTTP currently.
    - In the future, it is suggested to use HTTPS instead of HTTP and implement CSRF token to protect the web app.

4. Third-party Libraries:

The project relies on third-party libraries and APIs (such as ChatGPT, Google Cloud, ROS). We need to make sure these components are up-to-date and secure. Vulnerabilities in third-party components can be exploited.

- **Potential Attacks:**

  Supply chain attacks, vulnerabilities in third-party code.

- **Consequences:**

  Malicious code execution, data breaches, system compromise.

- **Possible Mitigations:**
    - Use reputable, well-maintained libraries.
    - Keep libraries up-to-date with security patches.
    - Conduct regular security assessments of third-party code.
    - Monitor for vulnerability disclosures in used libraries.
- **Specific Actions:**
    - We upgraded ROS to ROS2 which is the latest version with better security.
    - We upgraded NAO robot library from NAO SDK to NAO qi framework.

5. Secure Handling of API Keys and Tokens

OpenAI tokens, Google application credentials and other API keys, which are used for accessing third-party APIs, should be handled securely. Storing them directly in code (we found in one of the previous project), especially in public repositories, is a security risk. It's advisable to store API keys and tokens as environment variables or use a secure configuration management system to protect sensitive credentials.

- **Potential Attacks:**

  Exposure of sensitive tokens, API abuse.

- **Consequences:**

  Unauthorized data access, data leaks, unauthorized actions, API rate limiting.

- **Possible Mitigations:**
    - Store API keys and tokens as environment variables.
    - Use a secure secrets management solution.
    - Limit token privileges to the minimum necessary.
    - Rotate keys and tokens regularly.
- **Specific Actions:**
    - We removed the hard coded keys and avoided upload any keys or credential files onto online repository.
    - We used environment variables to save API keys.
    - We followed OpenAI Best Practice for API Key Safty.

6. Insecure Connections with the NAO Robot

The communication between the software components and the robot should be secured. If not properly configured, the connections could be vulnerable to eavesdropping or tampering by malicious actors. Implement encryption and authentication mechanisms to protect the integrity and confidentiality of data exchanged with the robot.

- **Potential Attacks:**

  Man-in-the-middle attacks, eavesdropping on robot commands, unauthorized control.

- **Consequences:**

  Unauthorized robot actions, privacy violations, potential physical harm.

- **Possible Mitigations:**
    - Keep the robot libraries up-to-date with security patches.
    - Use secure communication protocols between the software and robot.
    - Use strong authentication mechanisms.
    - Physically secure the robot to prevent tampering.
- **Specific Actions:**
    - We upgraded to the latest robot libraries (ROS2 and qi framework)

7. Container Security

Docker containers are used in the project, so there are security considerations to address. Exposing unnecessary ports within containers can create potential security vulnerabilities. Ensure that only essential ports are exposed, and follow best practices for securing Docker containers, including using official base images, updating containers regularly, and restricting container privileges.

- **Potential Attacks:**

  Container breakout, privilege escalation, unauthorized access.

- **Consequences:**

  Unauthorized access to host system, data leaks, container compromise.

- **Possible Mitigations:**
  - Follow container security best practices.
  - Minimize exposed ports and limit container privileges.
  - Use official base images and regularly update containers.
  - Monitor container activity for anomalies.
- **Specific Actions:**
  - We used the official ROS2 image as base image.
  - We used volume to store sensitive data (API keys and credentials).
  - We avoided using root privilege by creating a user "nao" and limited access to only project related folders and files.
  - We followed Docker Development Best Practices.

Cyber Security Issues Records

Issues	Status	How we solve it
Data Privacy and Protection	Sprint 3	We provide a contract for users to make ensure their right in legal. We limit the data collected from the children to only necessary information (name, birth date, handedness, gender). In addition, It is optional to provided any of these information. Currently, our web app is only for user interface. It is hosted on the local network and the data will only be saved in client's laptop. Therefore, the possibility of sensitive data being exposed is low.
Third-party Libraries	Sprint 3	We applied reliable libraries and API in our project. For example, we using OpenAI for generate related image and conduct the communication. Besides, we deployed https://www.pen-to-print.com/ as a OCR API for identify the struggle letters.
Secure Handling of API Keys and Tokens	Sprint 3	The API used in this project are only visitable form our won local computer, we only provide a example file to guide user how to implement theirs.
Container Security	Sprint 2 & 3	Docker containers are used in the project, so there are security considerations to address. Exposing unnecessary ports within containers can create potential security vulnerabilities. Ensure that only essential ports are exposed, and follow best practices for securing Docker containers, including using official base images, updating containers regularly, and restricting container privileges.

| Code Review

Sprint 2

The code review conducted on GitHub is available here.

We could not run the GitHub action to use ChatGPT for the code review (the number of tokens requested was too high). Hence, we did it manually.

General Remarks

- constants should be used more often and not be redefined twice. For example, if some constants are used in two different packages with different source code, a good idea could be to create a "global constants" module that could be imported in both packages. If one of the constant values had to be modified, the modification would only happen one time and be reflected wherever the value is used. Moreover, it reduces the chances of typo that could lead to bugs and/or crashes.
- respect the chosen coding standards (camel case to name classes or functions, use capital letters to define constants)
- tokens (such as OpenAI ones) must not be hardcoded and put in the source code. They must be declared in an environment file that must not be pushed to GitHub (use the .gitignore file). Then use a module like Python `os` to
- a lot of commented code is still present in the source code
- sometimes the files are too long and hard to read. For example, the ChatGPT related parts such as phrases, prompt declarations or image generation could be migrated into a distinct module for visibility. Currently, the AI related code is split in two different packages.

Sprint 3

As for sprint 2, we conducted the code review manually. Indeed, we could not run the GitHub action to use ChatGPT (the number of tokens requested was too high).

Nevertheless, we managed to comment the different commits directly on GitHub (PR link), but we also did more pair programming sessions which included code reviews.

These sessions mostly consisted in integrating new features developed by a team member in the project architecture. Each time the process was the same, we:

- started by reviewing the developed code and ensuring it was running without errors
- packed it into a new ROS2 node and established the appropriate connections with the other existing ones
- created new API routes so that the components on the frontend could communicate smoothly with the added code chunks.

That way of doing the code review was more efficient than the one chosen during sprint 2. Indeed, the changes and corrections were made on the spot and the reviewer could give live feedback and explanations to the developer.

According to the coding standards we decided to apply during this project, the most common remarks were the following:

- use appropriate naming to make the code more understandable and readable: for example, instead of doing "for l in user_inputs" do "user_input in user_inputs"
- use constants to declare a parameter only once and import it each time it is needed instead of declaring it each time it is needed. This can lead to typos which produce bugs.
- do not push or hard code API tokens in the source code, use an environment file instead.

| Appendix

Appendix A - Planning Poker

Appendix B - Trello