Mechatronics 4CCE1MCP Individual Coursework Project

Autonomous Control Design of a Ship for Environmental Clean-up

Module Instructors

- Dr Francesco Ciriello, francesco.ciriello@kcl.ac.uk

Throughout **4CCE1MCP Design: Making a Connection**, you will investigate innovative solutions for the collection of floating marine debris. You will combine simulation-driven analysis with hardware experimentation to deliver a scaled-down prototype of your design at the end of the semester. We encourage you to explore multiple design solutions and reflect on what improves your design.

In this document, you are provided with information to complete the individual coursework assessment for the course. This short project will be an opportunity to gain intuition about the system you will build and to compete with your classmates on a control design solution.

Submission deadline: End of Week 26, Feb 18th, 2022

Context

Problem: Each year, millions of tonnes of waste and pollutants enter the ocean (The Ocean Clean-up 2021). This waste causes significant environmental impact as it washes on our beaches, deposits on the ocean floor, and gets consumed by marine wildlife. A substantial portion of waste floats and accumulates in rotating ocean currents (NOAA 2021). The biggest accumulation of marine debris is the Great Pacific Garbage Patch that is located between Hawaii and California (see Figure 1) and expands over 1.6 million square kilometres (The Ocean Clean-up 2021).

Figure 1: A close-up photograph of the Great Pacific Garbage Patch.
Source: Forbes (2019)

Proposed Engineering Solutions: Several organisations are examining how to minimise and remove non-degradable waste that is being inappropriately disposed of in the ocean (Oceana,

The Ocean Cleanup, River Cleaning, Ichthion). While international waste directives recognise the necessity of reducing and collecting waste at source (EU Waste Directive 2018, UK Waste Directive Amendments 2020), these organisations recognise that the clean-up of existing debris is an important strategy to safeguarding the health of oceans and marine wildlife.

Popular collection strategies involve collecting waste directly at accumulation points (see Figure 2). River estuaries have been identified as a viable collection point (The Ocean Cleanup 2021). Debris collects in river catchment areas and acts as a conveyor belt that disperses waste into the ocean. Waste is intercepted and sorted at the estuary.

Floating waste dispersed into the ocean can sink to the floor or float away into oceanic currents. While most of the floating debris gets deposited on the coastline, a portion of the floating debris collects in rotating ocean currents. The resulting waste deposits contain millions of tonnes of waste (see Figure 1) and have also been identified as a viable collection point.

Figure 2: (left) The interceptor collects effluents from a river, (right) waste collection in Ocean
Source: The Ocean Cleanup 2021

Autonomous Operation: It is desirable to have machines that can replace humans in dull, dirty, difficult, and dangerous tasks. While automation has served this purpose since the Industrial Revolution, in recent years there has been a surging interest in intelligent, autonomous systems that can operate with little to no human intervention.

Autonomous machines are playing an increasingly important role in environmental restoration. We are seeing new designs that allow robots to sort and recycle household waste, drones that can re-plant forests by dropping seeds over unprecedentedly large areas and autonomous tractors that can farm the land. In this project, you will investigate how to incorporate autonomy in the ship collection system that you design.

Brief

For the individual coursework assessment, you will develop an autonomous control algorithm and test the algorithm in simulation for the clean-up scenario provided (see Figure 2). This will help you prepare for the design, build and test group project.

Starter files can be downloaded from the KEATS module page.

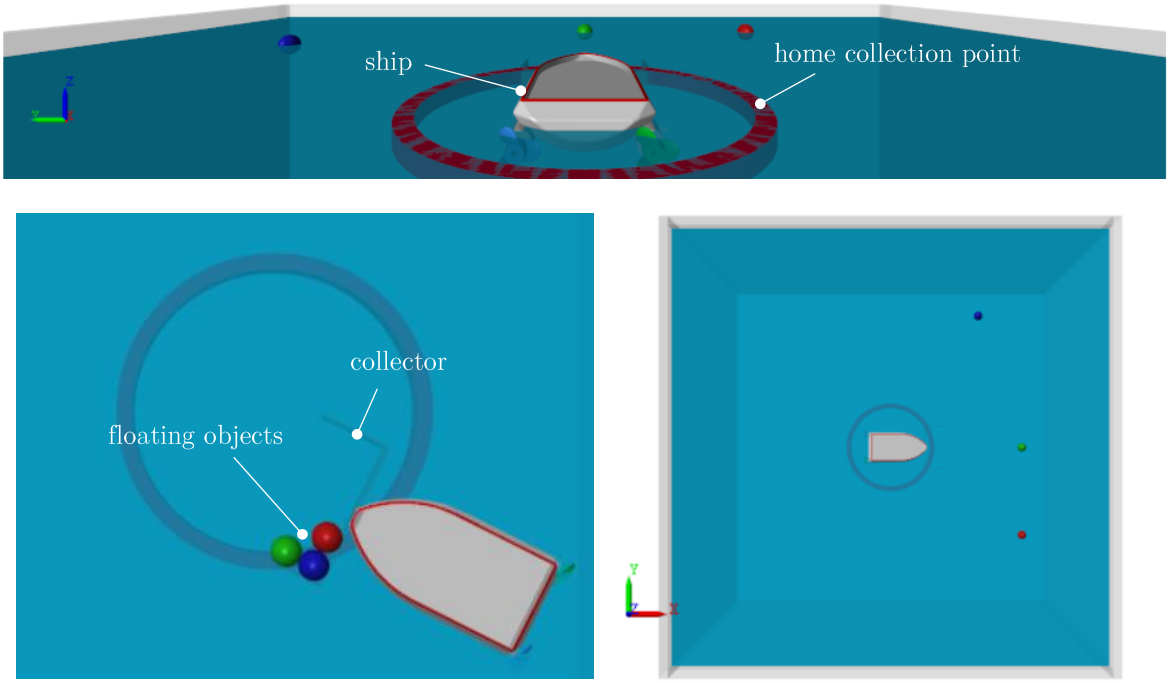


Figure 2: Simulation scenario
`ship_template.slx`

You are responsible for:

- designing a digital motor controller that can autonomously collect all floating objects in the provided scenario and return them to the home collection point (see Figure 2);
- optimising design dimensions (length and width of components) for the ship collector relative to your controller design;
- testing the effectiveness of your design through simulation;
- submitting a version of your design for assessment;
- competing for the quickest clean-up time for the provided scenario.

Deliverables

- a simulation submission file that is compliant with the specification outlines specified in the Instruction for Submission Section.
- a video of the ship simulation, recorded at playback speed of x8, see instructions here.
- a zipped folder where the project model and data can be shared with assessors.

Learning objectives

- Implement a logic-driven controller to define operating modes for the ship and to sweep an area
- Implement and tune an open-loop controller to control ship motion and steering
- Specify component parameters for the collector based on a simulation-driven design analysis
- Test controller design in simulation

Marking Criteria

Individual coursework submission accounts for 25% of module grade.

You will be judged on how quickly you managed to complete the scenario in simulated time.

Metric	**Marks Awarded**
Return three or more objects to base in less than 3 min in simulated time	10
Return five or more objects to base in less than 3 min in simulated time	5
Return seven or more objects to base in less than 2 min in simulated time	5
Return all nine objects to base in less than 2 min in simulated time	5

Plagiarism warning: Your submissions will be tested for plagiarism, so make sure your entry is unique.

Automated assessment warning: Ensure that your simulation runs in less than 5 minutes of real time computation, or the automated assessments scripts will timeout.

Instructions for submission

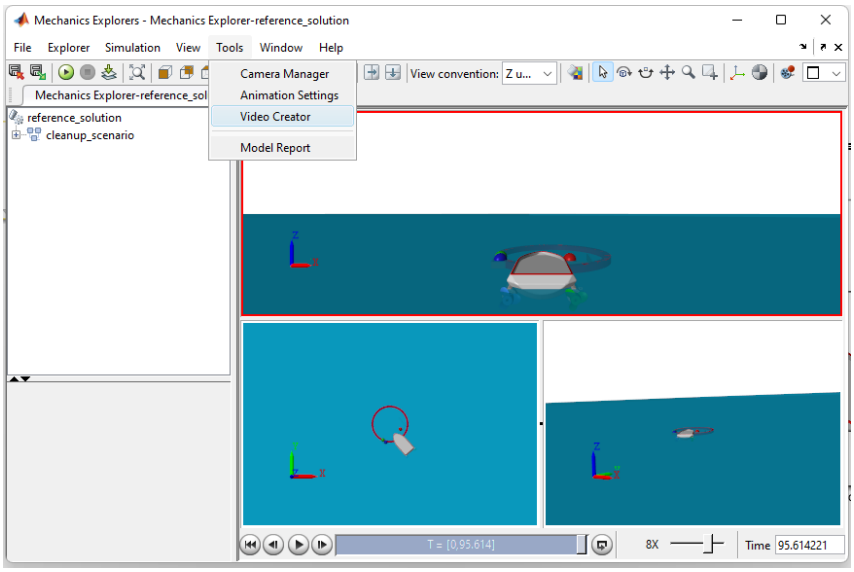
How to use the simulation submission template

Download the `ship_template.slx` model. Rename the file by appending your k-number to the filename, *e.g.* `ship_k1234567.slx`

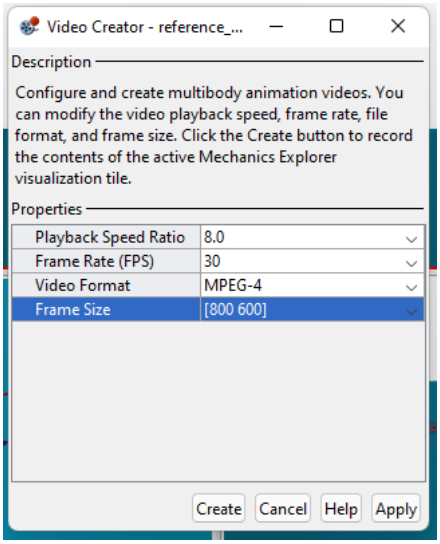
You will design your controller in this file. When completed, upload the model as an assignment to KEATS.

How to record a video in Simscape Multibody

1. Run the `ship_template.slx` model and locate the Mechanics Explorer window.
2. From Mechanics Explorer, select Tools > Video Creator from the menu tab.



3. Choose video settings below and click on Create.



4. Save the file as ship_k1234567.mp4
5. Upload the video recording to the KEATS assignment.