2024 MCM
Problem B: Searching for Submersibles

Maritime **C**ruises **M**ini-**S**ubmarines (**MCMS**), a company based in Greece, builds **submersibles** capable of carrying humans to the deepest parts of the ocean. A submersible is moved to the location and deployed untethered from a host ship. MCMS now wishes to use their submersible to take tourists on adventures exploring the bottom of the Ionian Sea for sunken shipwrecks. Before they can do this, however, they need to win approval from regulators by developing safety procedures in case of a loss of communication to the host ship and possible mechanical defects including a loss of propulsion of the submersible. In particular, they would like you to develop a model to predict the location of the submersible over time. Unlike in a typical search and rescue on land or on the surface of a sea, the defective submersible could potentially find itself positioned on the sea floor or at some point of **neutral buoyancy** underwater. Its position could further be affected by currents, differing densities in the sea, and/or the geography of the sea floor. Your tasks are to:

- **Locate** - Develop a model(s) that predicts the location of the submersible over time.
  - What are the uncertainties associated with these predictions?
  - What information can the submersible periodically send to the host ship to decrease these uncertainties prior to an incident? What kinds of equipment would the submersible need to do so?

- **Prepare** - What, if any, additional search equipment would you recommend the company carry on the host ship to deploy if necessary? You may consider different types of equipment but must also consider costs associated with availability, maintenance, readiness, and usage of this equipment. What additional equipment might a rescue vessel need to bring in to assist if necessary?

- **Search** - Develop a model that will use information from your location model(s) to recommend initial points of deployment and search patterns for the equipment so as to minimize the time to location of a lost submersible. Determine the probability of finding the submersible as a function of time and accumulated search results.

- **Extrapolate** - How might your model be expanded to account for other tourist destinations such as the Caribbean Sea? How will your model change to account for multiple submersibles moving in the same general vicinity?

Prepare a report of no more than 25 pages providing the details of your plan. Include a two-page memo of your report addressed to the Greek government to help win approval.

Your PDF solution of no more than 25 total pages should include:

- One-page Summary Sheet.
- Table of Contents.
- Your complete solution.
- Two-page memo.
- References list.
- AI Use Report (If used does not count toward the 25-page limit.)

Note: There is no specific required minimum page length for a complete MCM submission. You may use up to 25 total pages for all your solution work and any additional information you want to include (for example: drawings, diagrams, calculations, tables). Partial solutions are accepted. We permit the careful use of AI such as ChatGPT, although it is not necessary to create a solution to this problem. If you choose to utilize a generative AI, you must follow the COMAP AI use policy. This will result in an additional AI use report that you must add to the end of your PDF solution file and does not count toward the 25 total page limit for your solution.

Glossary

Submersible: A submersible is an underwater vehicle which needs to be transported and supported by a larger watercraft or platform. This distinguishes submersibles from submarines, which are self-supporting and capable of prolonged independent operation at sea.

Neutral buoyancy occurs when an object's average density is equal to the density of the fluid in which it is immersed, resulting in the buoyant force balancing the force of gravity that would otherwise cause the object to sink (if the body's density is greater than the density of the fluid in which it is immersed) or rise (if it is less). An object that has neutral buoyancy will neither sink nor rise.

Use of Large Language Models and Generative AI Tools in COMAP Contests

This policy is motivated by the rise of large language models (LLMs) and generative AI assisted technologies. The policy aims to provide greater transparency and guidance to teams, advisors, and judges. This policy applies to all aspects of student work, from research and development of models (including code creation) to the written report. Since these emerging technologies are quickly evolving, COMAP will refine this policy as appropriate.

Teams must be open and honest about all their uses of AI tools. The more transparent a team and its submission are, the more likely it is that their work can be fully trusted, appreciated, and correctly used by others. These disclosures aid in understanding the development of intellectual work and in the proper acknowledgement of contributions. Without open and clear citations and references of the role of AI tools, it is more likely that questionable passages and work could be identified as plagiarism and disqualified.

Solving the problems does not require the use of AI tools, although their responsible use is permitted. COMAP recognizes the value of LLMs and generative AI as productivity tools that can help teams in preparing their submission; to generate initial ideas for a structure, for example, or when summarizing, paraphrasing, language polishing etc. There are many tasks in model development where human creativity and teamwork is essential, and where a reliance on AI tools introduces risks. Therefore, we advise caution when using these technologies for tasks such as model selection and building, assisting in the creation of code, interpreting data and results of models, and drawing scientific conclusions.

It is important to note that LLMs and generative AI have limitations and are unable to replace human creativity and critical thinking. COMAP advises teams to be aware of these risks if they choose to use LLMs:

- Objectivity: Previously published content containing racist, sexist, or other biases can arise in LLM-generated text, and some important viewpoints may not be represented.
- Accuracy: LLMs can ‘hallucinate’ i.e. generate false content, especially when used outside of their domain or when dealing with complex or ambiguous topics. They can generate content that is linguistically but not scientifically plausible, they can get facts wrong, and they have been shown to generate citations that don’t exist. Some LLMs are only trained on content published before a particular date and therefore present an incomplete picture.
- Contextual understanding: LLMs cannot apply human understanding to the context of a piece of text, especially when dealing with idiomatic expressions, sarcasm, humor, or metaphorical language. This can lead to errors or misinterpretations in the generated content.
- Training data: LLMs require a large amount of high-quality training data to achieve optimal performance. In some domains or languages, however, such data may not be readily available, thus limiting the usefulness of any output.

Guidance for teams

Teams are required to:

1. **Clearly indicate the use of LLMs or other AI tools in their report,** including which model was used and for what purpose. Please use inline citations and the reference section. Also append the Report on Use of AI (described below) after your 25-page solution.
2. **Verify the accuracy, validity, and appropriateness** of the content and any citations generated by language models and correct any errors or inconsistencies.
3. **Provide citation and references, following guidance provided here.** Double-check citations to ensure they are accurate and are properly referenced.
4. **Be conscious of the potential for plagiarism** since LLMs may reproduce substantial text from other sources. Check the original sources to be sure you are not plagiarizing someone else's work.

COMAP will take appropriate action when we identify submissions likely prepared with undisclosed use of such tools.

Citation and Referencing Directions

Think carefully about how to document and reference whatever tools the team may choose to use. A variety of style guides are beginning to incorporate policies for the citation and referencing of AI tools. Use inline citations and list all AI tools used in the reference section of your 25-page solution.

Whether or not a team chooses to use AI tools, the main solution report is still limited to 25 pages. If a team chooses to utilize AI, following the end of your report, add a new section titled Report on Use of AI. This new section has no page limit and will not be counted as part of the 25-page solution.

Examples (this is *not* exhaustive – adapt these examples to your situation):

Report on Use of AI

1. OpenAI *ChatGPT* (Nov 5, 2023 version, ChatGPT-4)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

2. OpenAI *Ernie* (Nov 5, 2023 version, Ernie 4.0)
   Query1: *<insert the exact wording of any subsequent input into the AI tool>*
   Output: *<insert the complete output from the second query>*

3. Github *CoPilot* (Feb 3, 2024 version)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

4. Google *Bard* (Feb 2, 2024 version)
   Query: *<insert the exact wording of your query>*
   Output: *<insert the complete output from the AI tool>*