2024 IM²C
Picking the Perfect Pet

Background

Throughout history, humans and animals have coexisted, relying on each other for aid and comfort. From offering companionship, to serving as hunting partners or providing other manual labor, our connection with animals runs deep. Recent estimates suggest that more than half of people worldwide have a pet of some kind in their household,[1] from the more conventional dogs and cats to birds, rodents, and even the more exotic **species** such as snakes and amphibians. Whether they walk, fly, swim, or crawl; furry, feathered (or scaled) friends continue to support and comfort people across the globe.

During the height of the COVID-19 pandemic, countries and regions around the world saw a substantial increase in the number of **households** with pets,[2][3] highlighting the comfort and companionship pets offer in challenging times. The surge in pet ownership, however, also underscored the complexities of pet-human relationships. Unprepared or uninformed new owners often lead to pets being returned to shelters or abandoned,[4][5] contributing to the substantial number of stray animals across the world. This leads to potentially difficult living situations for the animal while also posing health risks to humans and other animals.[6][7]

Your Task:

The **I**nternational **M**ission for the **M**aintenance and **C**are of **A**nimals (IMMC-A), an organization concerned with the well-being of all potential pets, is asking your team to help them develop a quantitatively focused approach to pet ownership that benefits both animals and humans. More specifically, the IMMC-A needs your assistance in building mathematical models to determine which households are prepared to own a pet, how many households are pet-ready, and to forecast future pet ownership.

The IMMC-A acknowledges the diverse range of animals considered pets across different cultures, including species traditionally seen as farm or work animals in some countries/regions. This diversity presents unique challenges in defining what constitutes a pet. Therefore, your team will need to establish a clear definition of 'pet' that will inform your analysis and modeling.

1. **Warm up (with cats).** Develop a mathematical model that can be utilized by an animal shelter, pet store, or similar entity to evaluate a household's readiness for cat ownership. In other words, your model needs to be able to receive information from a given household and determine if the household is prepared to own a cat.

   [Please note that the IMMC-A values user-friendly models. Thus, to promote utilization, your model cannot require more than ten input factors from a household. Justification of your team's choices will play an important role in your model's viability. Additionally, you should create a diagram that clearly explains your model's decision-making process.]

   a. What does a cat-ready household 'look like'? Validate your model's ability to capture the diversity of households that could have a cat as a pet. Provide at least three examples of households that qualify for cat ownership in a country/region of your choosing and at least three that do not qualify. Be sure to choose examples that highlight the factors, or combination of factors, that your model associates most readily with households that qualify for cat ownership.

   b. Assess your model on a broader scale (and/or adjust it if necessary) by using it to determine the current number of households that are prepared to own a cat in *three* countries/regions of your choosing.

2. **Generalize your model** from question #1 (i.e., re-use, adjust or alter as needed) so that it still accepts ten (or fewer) inputs but now returns output that addresses a household's pet preparedness for cats as well as *four additional pet species* of your choice.

   a. Demonstrate your model's utility by reviewing the pet preparedness of at least six households located in the same country / region you originally considered in question #1a. You may choose to analyze the same households you used earlier, but make sure to discuss the significance of the examples you've chosen to highlight.

   b. Some households possess multiple pets. How does your model address this situation?

3. **The future of pet ownership.** Using your previous model(s) as a tool for *potential* pet ownership, project future pet demographics. Specifically, develop a mathematical model that projects pet ownership and retention (i.e., pets kept in their original household) in five, ten and 15 years by pet species. Consider the same three countries/regions you identified in question #1b and the same five pet species (cats plus your four pet choices) you used in question #2.

Your PDF submission should consist of:

- One-page Summary Sheet.
- One-page *Letter to the Decision Makers* with your recommendation.

  o Write a one-page letter to the Directors of the IMMC-A with your recommendation for how potential pets should be matched with humans and why this will result in a positive change in the overall health of domesticated animals and people worldwide. The IMMC-A Directors are familiar with the problem of having many homeless former pets and crowded animal shelters (and have just read your Summary Sheet so do not restate or repeat this). They are interested in a humane solution that promotes pet ownership but decreases pet abandonment. Keep in mind that the purpose of the letter is to provide essential information to the decision makers, communicating key details of your full recommendation as stated in your solution paper.

- One-page Table of Contents.
- Your complete solution. Twenty pages (maximum) communicating essential aspects of your solution.
- Reference List.
- AI Use Report (if used).
- The following items <u>do not</u> count toward the 23-page limit: Reference List and Appendices (including AI Use Report).

Note: There is no specific required minimum page length for a complete IM²C submission. 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 IM²C 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 <u>does not</u> count toward the 23 total page limit for your solution.

Your PDF submission paper must be typed and in English using A4, margins at least 1.5cm (OR) Letter, margins at least 0.6in with at least 12-point font size. For detailed information about IM²C submission guidelines and the general expectations for each portion of your solution please review the Full Submission Guidelines.

Glossary
- A **household** is classified as either:
  (a) A one-person household, defined as an arrangement in which one person makes provision for his or her own food or other essentials for living without combining with any other person to form part of a multi-person household or
  (b) A multi-person household, defined as a group of two or more people living together who make common provision for food or other essentials for living.[8]
- A biological **species** is a group of living organisms that can reproduce with one another in nature and produce fertile offspring.

References

[1] *Man's best friend: Global pet ownership and feeding trends.* GfK.com (2016, November 22). https://www.gfk.com/insights/mans-best-friend-global-pet-ownership-and-feeding-trends

[2] *Pets and the Pandemic: A social research snapshot of pets and the people in the COVID-19 era.* Animal Medicine Australia. (2021, August 16). https://animalmedicinesaustralia.org.au/wp-content/uploads/2021/08/AMAU005-PATP-Report21_v1.41_WEB.pdf

[3] *New Pet Population Data released.* ukpetfood.org (2021, March 22). https://www.ukpetfood.org/resource/pfma-releases-latest-pet-population-data.html

[4] Wollaston, S. (2021, December 1). *Rescue me: why Britain's beautiful lockdown pets are being abandoned.* The Guardian. https://www.theguardian.com/lifeandstyle/2021/dec/01/rescue-me-why-britains-beautiful-lockdown-pets-are-being-abandoned

[5] Intake and Outcome Database. Shelter Animals Count https://www.shelteranimalscount.org/intake-and-outcome-database-iod/ (accessed 2024, January 31)

[6] Zero Stray Pawject. https://www.zerostraypawject.org/strays-explained (accessed 2024, January 31)

[7] *Stray Animals: Pets Without a Home* (2023, August 10) Four Paws.
https://www.fourpawsusa.org/campaigns-topics/topics/help-for-strays/stray-animals-pets-without-a-home

[8] Demographic and Social Studies: Households and families. U.N. Statistics Division
https://unstats.un.org/unsd/demographic-social/sconcerns/family/#docs (accessed 2024, January 31)

Use of Large Language Models and Generative AI Tools in the IM²C

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, IM²C 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 considered plagiarism and disqualified.

Solving the problems does not require the use of AI tools, although their responsible use is permitted. The IM²C 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.

If, for example, you are writing your IM²C article in a language other than English and translating to English using LLMs or reading an article in English and translating into another language for understanding in your AI report please state, "we used LLMs for translation purposes."

However, 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. IM²C 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 23-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.

**IM²C 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 23-page solution.

Whether or not a team chooses to use AI tools, the main solution report is still limited to 23 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 23-page solution.

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

<u>Report on Use of AI</u>

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>*

2024 IM²C Full Submission Guidelines

Teams may use any inanimate source of data, materials, computers, software, references, websites, books, etc. Be sure to credit all sources used.

Teams may not use any person (other than team members) to discuss or obtain ideas for solving their problem **nor may they seek help in obtaining an answer from the teams' advisor or anyone else**. Any team that discusses the problem with anyone in a position to supply them with information reflecting experience or professional expertise will be disqualified. The relevant issue is one of intent: each team of students is expected to develop all of its substantive analysis without the help of others.

Partial solutions are acceptable. There is no passing or failing cutoff score, nor will numerical scores be assigned. The IM²C judges are primarily interested in a teams' approach and methods.

The solution must consist entirely of written text and possibly figures, charts, or other written material only. No non paper support such as computer disks or applications will be accepted.

Each page of the solution should contain the team control number and the page number at the top of the page; we suggest using a page header on each page for example: Team # 2024000 page 6 of 13.

The names of the students, advisor, or institution must not appear on any page of the solution. The solution must not contain any identifying information other than the team Control Number.

Teams should keep in mind the following guidelines while preparing their solution papers:

- Conciseness and organization are extremely important. Key statements should present major ideas and results.
- Present a clarification or restatement of the problem as appropriate.
- Present a clear exposition of all variables, assumptions, and hypotheses.
- Present an analysis of the problem, motivating or justifying the modeling to be used.
- Include a design of the model. Discuss how the model could be tested.
- Discuss any apparent strengths or weaknesses to your model or approach.
- Incorporate lengthy derivations, computations, or illustrative examples in appendices. Summarize these in the main report. Results must be explicitly stated in the body of the report.

Your PDF solution should include:

- **One page Summary Sheet.**

  The Audience for the summary sheet is anyone unfamiliar with the problem. Hence, in your own words briefly outline the problem, the main solution approach, and your conclusion.

To write a good summary, imagine that a reader may choose whether to read the body of the paper based on your summary. Thus, a summary should clearly describe your approach to the problem and, most prominently, what your most important conclusions were. The summary should inspire a reader to learn the details of your work. Your concise presentation of the summary should inspire a reader to learn the details of your work.

- **One page *Letter to the Decision Makers* with your recommendation.**

  The audience is the Directors of the IMMC-A, a group that is interested in learning your recommendation for how potential pets should be matched with humans and why this will result in a positive change in the overall health of domesticated animals and people worldwide. They are already familiar with the problem (and have just read your Summary Sheet so don't restate or repeat this). Keep in mind that the purpose of the letter is to provide essential information to the decision makers, communicating key details of your full recommendation as stated in your solution paper.

- **One page Table of Contents.**

  This allows the reader to easily find various parts of your solution, especially if they chose not to read though in order (as is typical when reading long reports).

- **Twenty-page** (maximum) **report** communicating the essential aspects of your solution.

- The specifications of a complete solution:
    - A4, margins at least 1.5cm (OR) Letter, margins at least 0.6in
    - Papers must be typed and in English.
    - At least 12-point font size.
    - **Note that (excluding references and appendices, see below) you have a maximum of 23 pages to communicate your solution.** Your summary sheet, letter to the decision makers and your table of contents all count towards the 23-page limit (excluding references and appendices) of your solution.
- **Reference List, Appendices, and AI Use Report.**

  A list of references, any appendices, and the AI Use Report, ***do not count*** toward the 23-page limit and should appear after your completed solution. You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources of all ideas and materials (data, images, etc.) so it is clear to the reader what ideas and mathematical work was completed by your team and where you are building in ideas of others.