Instructions:

- *Your solutions for this tutorial must be TYPE-WRITTEN.*
- *Submit your PRINTED solution(s) to your tutor. You can make another copy for yourself if necessary. Late submission will NOT be entertained.*
- *YOUR SOLUTION TO QUESTION* 1 *will be GRADED for this tutorial.*
- *You can work in pairs, but each of you should submit the solution(s) individually.*
- *Include the name of your collaborator in your submission.*

1. You are tasked with the creation of an interactive agent that would be deployed in an automatic coffee-vending machine. The agent needs to work as a chatbot to converse with the user. Answer the questions below which would be crucial in the design of your agent:
   (a) How would you define the agents state and action space?
   (b) What would the utility function of the agent involve?
   (c) What kind of exploration actions could the system take?
   (d) For a highly flexible chatbot deployed as the agent, what kind of action should it refrain from taking?

Solution:

(a) The agent's *state* would comprise of attributes related to details of the coffee that is ordered:
   i. Type of coffee: e.g. espresso, americano, cappuccino, latte.
   ii. Size of the coffee cup.
   iii. Number of cups.
   iv. Hot or cold.
   v. Others.

   Attributes related to the process of ordering also has to be included. For example, the method of payment, whether payment has been made, whether coffee has been delivered, etc.
   The *action* space of the agent could comprise components that include conversing with user or instructing the machine for some event. Such as:
   i. Prompting user to fill missing details of state-space attributes. e.g. "How many cups of coffee would you want to have now?"
   ii. Initiating the preparation of ordered coffee in the machine, e.g. add sugar, add cream, etc.
   iii. Requesting the mode of payment .

Though the above process looks simple, the main challenge of the agent would be in acquiring information through natural dialog. Modern day chatbots achieve this by maintaining a dialogue manager which emulates the state space described above [1].

(b) A simple utility function would be to see whether the interaction leads to a successful transaction. Fine-grained utilities would involve the duration of the chat required to conclude the transaction, sentiment analysis on the user input, etc.

(c) One explorative action would be to suggest the user for a particular combination of drink. This can either lead to increased sales or frustrating users due to interference on their preference.

(d) The system has to refrain from gender, racial biases in the dialog [2]. Also, the system shouldn't inquire personal details during the course of the chat.

2. You have been appointed as the lead engineer in the development team of NUSmart Shuttle Bus - the new autonomous shuttle in NUS [3]. Define the characteristics of the task environment in which the shuttle has to be deployed. Support your answer with sufficient reasoning behind your choices.

   (a) Comment on the observability aspect of the environment.
   (b) Is the environment a single-agents, collaborative multi-agent or competitive multi-agent environment? Justify your answer.
   (c) Will the environment be deterministic or stochastic? Give an example scenario to support your answer.
   (d) Would you model the environment to be episodic or sequential? Explain your choice.

Solution:

(a) The environment would be *partially observable*. Though the shuttle might have a map of the overall route, it wouldn't be able to observe many attributes such as traffic conditions, pedestrians, etc.

(b) The environment would comprise of multiple-agents as components like *incoming cars* can influence the performance of our shuttle bus. In general, these agents can be assumed to be *collaborative* as incidents such as accidents hurts all. However, there might be traces of competitions between agents. For example, we might want to compete with a fellow company's agent over performance factors like total users transferred per day.

(c) The environment would be *stochastic*. For example, transition from a state using an action might result in a state where a new pedestrian comes onto the road. This element of *chance* in the resulting state makes the environment stochastic.

[1] https://web.stanford.edu/~jurafsky/slp3/24.pdf
[2] https://www.theverge.com/2016/3/24/11297050/tay-microsoft-chatbot-racist
[3] https://uci.nus.edu.sg/oca/latest-news/nusmart-shuttle-a-fully-autonomous-vehicle/

Figure 1: NUSmart autonomous shuttle.

(d) The environment should be modeled as *sequential*. This is particularly important for the agent to estimate utilities properly. For example, if the shuttle is speeding towards an obstacle, its percept sequence containing temporal information would allow to detect the need to de-accelerate early.

3. Are reflex actions (such as flinching your hand from a hot stove) rational? Are reflex actions intelligent?

   Solution: Yes, they are rational, because slower, deliberative actions would tend to result in more damage to the hand. If "intelligent" means "applying knowledge" or "using thought and reasoning" then it does not require intelligence to make a reflex action.

4. Weizenbaum's ELIZA program simulates the behavior of a psychotherapist carrying out a conversation with a patient. It basically works by finding keywords in the user's input so as to fire certain rules based on the keywords. Which AI definition does ELIZA fit in? (Thinking humanly? Acting humanly? Thinking rationally? Acting rationally?) Discuss how an ELIZA-like system will behave, if it is modeled according to each of the four agent types, namely, "simple reflex agent", "model-based reflex agent", "goal-based agent", and "utility-based agent".

   Solution: ELIZA fits in the "acting humanly" definition because it tries to mimic (behave like) human behavior but it does not make use of any human thinking or reasoning to give an answer.

A **simple reflex agent** will simply reply by matching the first successful rule or any randomly selected successful rule. **rule matching to percept.**

A **model-based reflex agent** will try to keep track of the state to monitor, for instance, what replies had been used before so that it would not keep replying with the same answer to the same or similar inputs. **model of world/env $\rightarrow$ state update.**

A **goal-based agent** will try to meet the goal of giving appropriate psychiatric help to the user. **goal: offer psychiatric help to user.**

A **utility-based agent** will consider various trade-offs among conflicting goals, like giving the quickest response or the least-cost treatment plan or the safest treatment plan, etc. **handle conflicting goals: least cost vs. effectiveness of treatment.**