ECE183DA PS1

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1 Vending Machine (Discrete Space)

- **Description**
  - This system is capable of dispensing objects according to the input it is given. The input is currency and product ID, after which the system will communicate (output) the status of the transaction and take the corresponding action whether it be to dispense an object, request more credit, request to be restocked, or stay idle waiting for user input.
- **State**
  - State Space = $S = \{s|s \in \{I, W, D, E, R\}\}$
  - State Descriptions:
    - I = Remain Idle waiting for input.
    - W = Wait for more credit or for user to make a selection.
    - D = Dispense selection and return change if appropriate.
    - E = Requested transaction required more credit.
    - R = Return credit.
- **Input**
  - Action Space = $A = \{a|a \in \{0, 1, 2, ..., 9, G\}\}$
  - Action Descriptions:
    - Digits $0 - 9$ correspond to user input specifying product ID
    - G = Request for credit to be returned
- **Output**
  - Observation Space = $O = \{o|o \in \{Y, C, X, M\}\}$
  - Observation Descriptions:
    - Y = Successful transaction.

    * C = Requires more credit.
    * X = Out of stock.
    * M = Waiting for decision or more credit.

- **Markov Property Justification**
  - The state representation for this system required only the current amount of credit in the system, the user input, and the current stock of products to transition between states. Future states of the system, whether it be to dispense a product, output an error message, or return credit, only depend on the present state and not past states thus satisfying the Markov Property.

- **Equation Formulation**
  - The transition probability set P for this system will consist mainly on how likely the system receives input successfully. With each iteration of user input, there is a chance that the system will produce an error and not be able to transition to the intended state. Therefore, to formulate the system dynamics, we must understand the probability of receiving input successfully, and also the probability that the transition of the state itself will be the correct one.
  - The output set O for this system relies directly upon the probability set P as its communication depends on what state the system is in. This means that there will be underlying probabilities (which involve the chance of the system making a state transition error or an input processing error) that will decide the output of the system.

2 Bid Price Calculator (Continuous Space)

- **Description**
  - This system calculates the most reasonable price that a bidder should offer for an object during an auction. It takes information about the situation of the object, and outputs a price based on its calculations when requested to do so.

- **State**
  - State Space $= S = \{x(t) | x(t) \in X \subset Q^+\}$
  - **note:** $x(t)$ is a continuous calculation that is consistently updated given the present environment inputs. It differs from the output in that the output only executes when requested, and it may be in different formatting depending on approximation. truncation, or self-imposed bias.

- **Input**

  - Action Space $= A = \{u(t)|u(t) \in U \subset Q^{3+}\}$
  - $U = \{u|u \in \{C, T, N\}\}$
    * C = Current highest bid in cents.
    * T = Time to expiry of bid in seconds.
    * N = Number of total bids.

- **Output**
  - Observation Space $= O = \{z(t)|z(t) \in Z \subset Q^{+}\}$
  - The output calculation will depend on how the user will like to weigh each of the inputs into the final calculation.

- **Markov Property Justification**
  - The state representation of this system depends solely on present inputs defining the number of bids that the object in question has, the current bid price, and current time to expiry. Therefore, future state transitions depend exclusively on the present state which is built recursively hence there is no dependency on past states, thus justifying the Markov property.

- **Equation Formulation**
  - The system dynamics here will be continuously updated every single second (still in discrete time) due to the input variable T which represents time to expiry in seconds. The state equation will be formulated as a rigorous calculation that includes elements of game theory probability and bidding theory.
  - The output equation will be responsible for reporting the most reasonable bidding price according to the calculation made by the system, along with biases that the user must define. For example, the user can define the output equation to include biases depending on the item that is on auction (if it is very important to them, make a higher/lower bid depending on strategy), the approximation method, and other strategic tools the user may prefer.