IE 579 PROJECT - OPTIMIZATION OF HUMAN-MACHINE COLLABORATION AND WAREHOUSE PERFORMANCE

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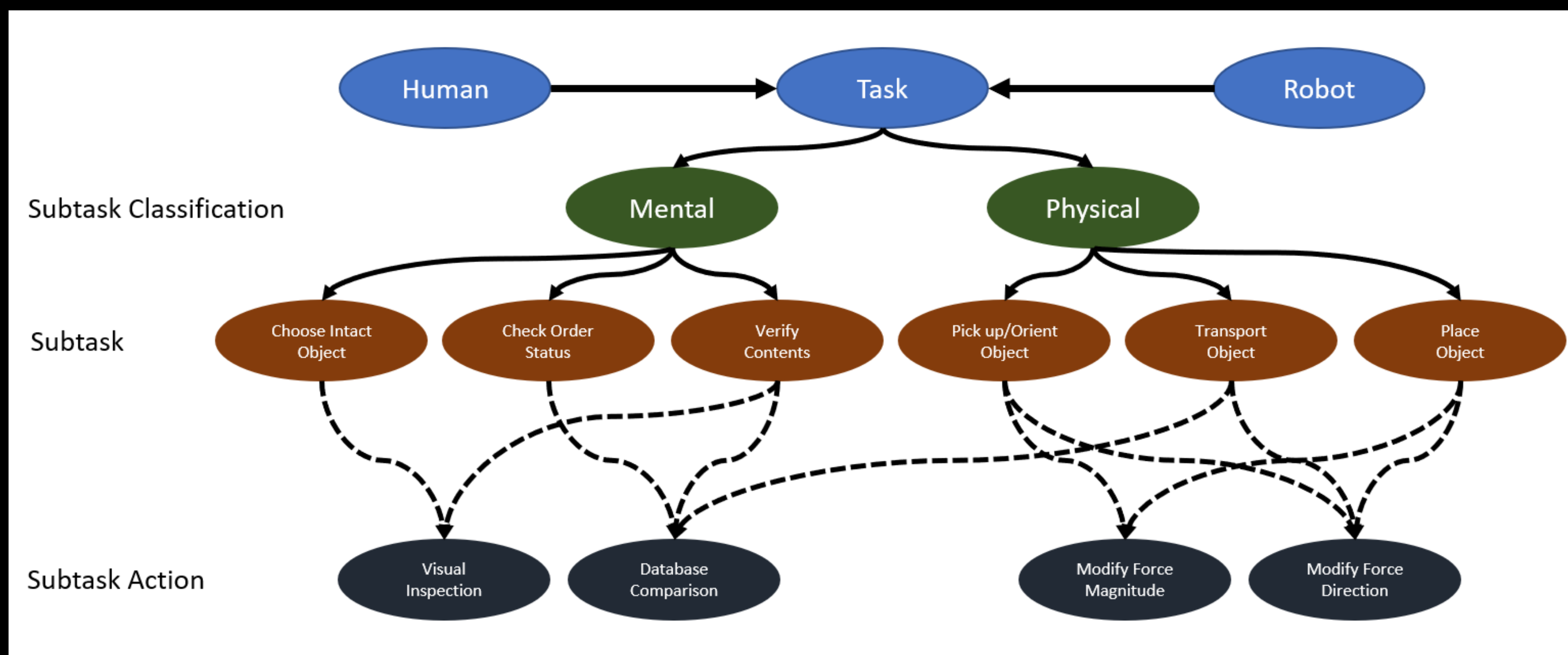
Task: Develop 4 models (one per team member) to describe the performance of human and machine agents in a warehouse environment. Use these models to predict optimal conditions given various operating parameters



Rohan's Contributions:

Informatic Model – Developed a model to describe the different tasks and subtasks performed by humans and robots in a warehouse environment. This model can be used to assess heuristically which tasks are better suited for humans or machines

Mathematical Model – Conducted a literature search to determine industrially-relevant optimization functions. Designed a basic optimization function that uses known weights for various variables (such as time, accuracy, and quality) to determine the optimal operator for a given task. This model also considers the absolute need for certain performance metrics (i.e., the task must have an accuracy of 1, etc.).

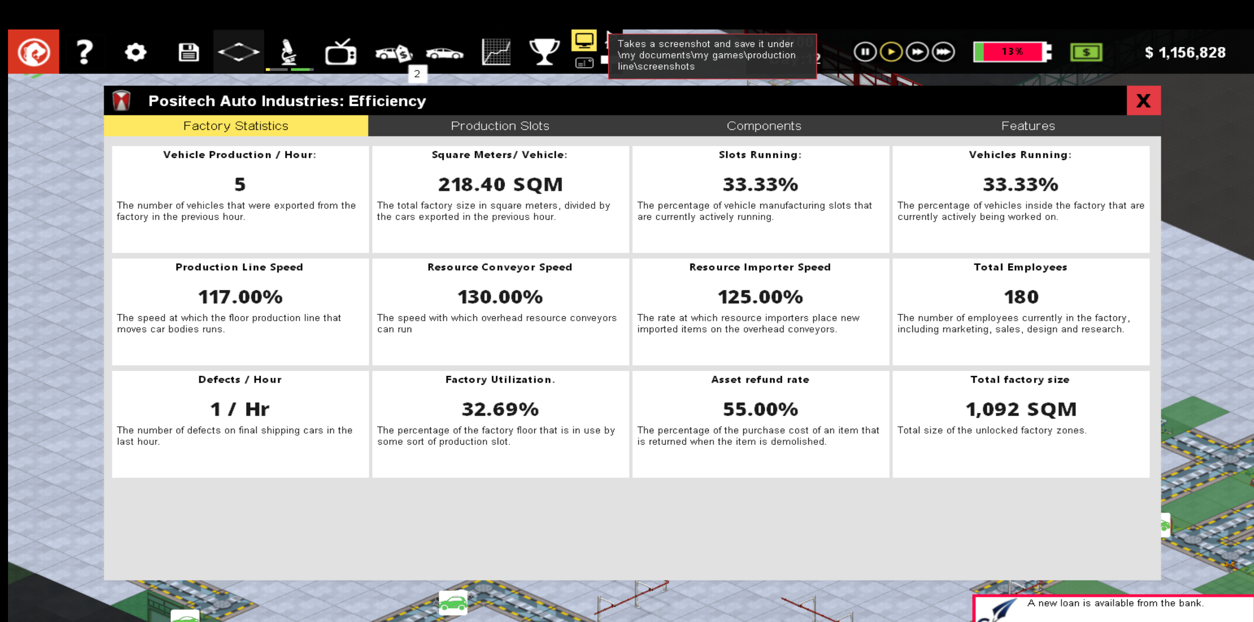
Simulation – Used a software simulator to apply principles of my mathematical model and validate it using simulated data

Course and Project Learnings:

Basic models to predict optimal process conditions for a given stochastic or deterministic system (EOQ models)

Mathematical modeling of real-life scenarios

Heuristic and objective decision-making



Thus, the optimization problem can be expressed as follows, with 3 optimization variables, as in Eq. 9.

$$\Omega(\alpha) = \min\left(\sum_i t_{ij} + \Xi_{ij} + \zeta_{ij}\right) \tag{9}$$

In order to relax mathematical constraints on this function (and thus, further generalize the result), we can simplify this model to consider only time as an optimization variable. In this model, we assume that the product **must** be accurate and of acceptable quality – thus, this is no longer an optimization variable but rather a constraint on the model. This yields Eq. 10.

$$\Omega(\alpha) = min \sum_i t_{ij} \tag{10}$$

s.t.

$$\sum_i \Xi_{ij} = 0 \;\; and \;\; \sum_i \zeta_{ij} = 0$$

This is essentially impractical, since it is basically not possible to have 100% accuracy. In some cases, a certain amount of accuracy and quality is sufficient, however. Thus, we can set bounds for accuracy and quality variables, instead, which gives Eq. 11 (I is the total number of task elements). Note that the weights on the bounds for Ξ and ζ are variable depending on the application.

$$\Omega(\alpha) = min \sum_i t_{ij} \tag{11}$$

s.t.

$$\sum_i \Xi_{ij} < 0.5I \;\; and \;\; \sum_i \zeta_{ij} < 0.5I$$

Thus, Eq. 9 can be used in the case that time, quality, and accuracy are of equal concern, Eq. 10 can be used if accuracy and quality must be perfect, and Eq. 11 can be used in cases where time is of paramount concern, but a certain specification must be met for accuracy and quality.