LLM Agents in Auctions and Negotiations

Assignment 2

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1. Introduction

This project implements a multi-agent simulation where LLM-powered agents negotiate construction contracts. The scenario involves a house owner (ACME) using:

1. Reverse Dutch Auctions to attract contractor interest.
2. Monotonic Concession Negotiations to finalize prices.

Agents are guided by structured prompts and respond using **OpenAI's GPT-4o**. ACME aims to assign all tasks at minimal cost, while companies seek at least one profitable contract.

2. Prompts

In this project, our prompt engineering approach is centered on **empowering** the language model with **full contextual awareness** while avoiding prescriptive or restrictive instructions. The main goal is to simulate rational, adaptive agent behavior by supplying the model with rich, structured data, but letting it reason freely within the game constraints.

To ensure consistent and strategic behavior, we designed the **system prompt** to clearly define the agent's role, objectives, and game rules. This helps the model understand its identity and priorities (minimize cost vs. maximize profit), while keeping it aligned with protocol constraints like round limits or monotonic concessions.

By stating these details upfront, we provide a **stable context** for reasoning, allowing the model to act rationally without enforcing logic in code. This approach encourages flexibility while ensuring decisions remain within the game's structure.

In the **user prompt**, we focus on delivering **concrete, structured data** relevant to the current decision, such as round number, budget, prior offers, company status, etc. The aim is to provide **all necessary inputs for reasoning**, while avoiding any instructions on *how* the model should decide.

This preserves the model's freedom to evaluate trade-offs, risks, and context dynamically, ensuring realistic and adaptive behavior, rather than hardcoded logic or rigid patterns.

We included the line "Think about it step by step, analyzing advantages and risks of its current situation." to **encourage explicit reasoning** from the model before producing its final answer.

This guides the model to perform **deliberate, transparent decision-making**, which improves robustness and allows us to inspect its thought process. It also mimics human-like strategic thinking, increasing the realism and interpretability of the agent's choices.

3. Game and Reasoning

GPT **completed the game** by using structured reasoning, guided by carefully engineered prompts that emphasized **situational analysis** rather than rigid instructions. For each decision point, whether proposing a budget or responding to an offer, the prompts encouraged the model to "think step by step," evaluating relevant factors such as budget limits, contractor status, round progression, past bids, and profit margins.

This approach enabled GPT to behave like a **rational agent**: in early rounds, it explored lower-cost options, while in final rounds, it prioritized completing contracts to avoid losing. The model dynamically **adjusted its strategy** based on contextual cues (favoring idle contractors or raising offers only when necessary) demonstrating an understanding of trade-offs between cost minimization and task completion. This reasoning-driven flexibility was key to finishing the game successfully under the defined constraints.