

L3MS — LAGRANGE LARGE LANGUAGE MODELS

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OPTIMIZATION FOR LLMs

1. **Pre-training**

- Minimize perplexity

2. **Supervised fine-tuning (SFT)**

- Minimize task related loss, e.g. perplexity

3. **Alignment**

- Maximize weighted sum of rewards
- Penalize for deviation

OPTIMIZATION FOR LLMs

How does one choose the weights for alignment?

- Application dependent
 - Chosen through trial and error
 - Involves verification against minimum requirements,
e.g. $r_{\text{harmless}} \geq b_{\text{harmless}}$
1. Can we avoid heuristics and enforce such minimum requirements in a principled way?
 2. Can we ensure the performance on the original task?

CONSTRAINED OPTIMIZATION FOR LLMs

Constrained optimization problem

- **Objective:** minimize task related loss
 - **Constraints:** maximize rewards till requirements are met
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- Merge SFT (objective) and alignment (constraints)
 - No reliance on heuristics
 - Allows for customization

LAGRANGE LARGE LANGUAGE MODELS (LLMs)

Employ logarithmic barriers

- Transforms the problem from constrained to unconstrained
- Amenable to stochastic gradient methods
- Connection to Lagrange multipliers (KKT conditions)

Constraints are gradually enforced, nudging the LLM to satisfy them over the optimization procedure

EXPERIMENTAL RESULTS: LENGTH CONSTRAINED L3Ms

Prompt	What are the four main types of macromolecules found in living organisms?
Response (short response L3M)	<ol style="list-style-type: none">1. Nucleic acids (DNA and RNA)2. Proteins3. Carbohydrates4. Lipids
Response (long response L3M)	<ol style="list-style-type: none">1. Nucleic acids, including DNA and RNA, which carry genetic information2. Proteins, which are responsible for the structure, function, and regulation of living organisms3. Lipids, which provide energy and form the membranes that surround cells4. Carbohydrates, which are used as an energy source and as structural components of cells.
Prompt	Who discovered the law of universal gravitation?
Response (short response L3M)	Sir Isaac Newton is credited with discovering the law of universal gravitation in the late 17th century.
Response (long response L3M)	Sir Isaac Newton is widely credited with the discovery of the law of universal gravitation, which states that every particle in the universe attracts every other particle with a force proportional to their masses and inversely proportional to the square of the distance between them.

Table 1: **Example responses from length constrained L3Ms.** We provide example responses from L3Ms with varying length constraints. We include the prompt along with the generated responses from two L3Ms; one constrained to have short responses and the other constrained to long ones.

THANK YOU!

