# Project Title:

**Smart Product Pricing System**
*(Developed under the Amazon ML Challenge 2025)*

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## Abstract

This project focuses on developing a **machine learning-based Smart Product Pricing System** that predicts the price of e-commerce products using both textual and visual data. The goal was to design a model capable of analyzing product information — including descriptions, bullet points, and images — to estimate fair and realistic prices.

To achieve this, our team built and compared multiple model architectures. The final approach combined **semantic text understanding** and **visual feature extraction** for accurate price prediction.
This work demonstrates the potential of multimodal learning for commercial applications such as pricing automation, catalog management, and recommendation systems.

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## Team Members

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## Mentors

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# 1. Problem Statement

In e-commerce, determining a fair product price requires balancing multiple features — product category, specifications, brand, and visual appeal. Manual pricing or rule-based systems fail to scale across large inventories.
The **Smart Product Pricing System** aims to automate this process using a **data-driven multimodal approach**, predicting prices based on product content and image data.

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# 2. Dataset Overview

The dataset consisted of two structured files — **train.csv** and **test.csv** — containing the following key attributes:

- **sample_id:** Unique product identifier
- **catalog_content:** Product description text with OCR details
- **image_link:** Product image URL
- **price:** Actual product price (in training data only)

Each record included a mix of textual and visual details. The task required the model to infer price patterns based on these two modalities.

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# 3. Approach and Model Design

We designed and evaluated two architectures to determine the most efficient combination of textual and visual understanding.

## Architecture 1 – Text-Based Model

- Focused only on the product's textual data.
- Implemented using a **BiLSTM network** with attention for contextual feature extraction.
- Final regression layer predicted product price.

**Performance:**

- Achieved consistent baseline results with moderate accuracy.

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### Architecture 2 – Multimodal Fusion Model

- Combined **text embeddings** and **image embeddings** into a unified representation.
- **Text Encoder:** BiLSTM + Attention layer.
- **Image Encoder:** Pretrained **ResNet** for visual feature extraction.
- **Fusion:** Concatenation of both embeddings followed by dense and regression layers.

**Performance:**

- Delivered improved accuracy and generalization.
- Demonstrated that integrating both modalities enhances pricing estimation.

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## 4. Implementation Workflow

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Text Input  → Preprocessing → Text Embedding (BiLSTM)
Image Input → ResNet Embedding → Fusion Layer → Dense + Regression → Predicted Price
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The pipeline was optimized for balance between model complexity and inference efficiency.

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## 5. Results

The final **Multimodal Fusion Model** achieved the best performance among all tested approaches, producing stable and accurate price predictions across diverse product categories.

This project was developed and evaluated under the **Amazon ML Challenge 2025**, where our team achieved an **approximate rank of 1500 out of 9000+ teams** nationwide — a result validating the reliability of our approach and implementation.

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## 6. Future Scope

- Explore **transformer-based multimodal architectures** such as CLIP or ViLT.
- Introduce **price range classification** alongside regression for hybrid prediction.
- Develop a simple **web dashboard** for real-time price estimation.
- Optimize performance using model compression and quantization.

# 7. Conclusion

The **Smart Product Pricing System** successfully demonstrates how machine learning can automate and enhance the pricing process for e-commerce platforms.
By integrating both text and image modalities, it achieves improved accuracy and adaptability across product categories.
This project provides a solid foundation for practical applications in automated catalog pricing and market value estimation.