

# The Judge & The Curve: Video Generation Report

## Project Overview

This educational video explains the mathematical foundations behind AI reward models and regression, demonstrating how Large Language Models learn to evaluate response quality through regression-based scoring systems.

**Duration:** 2 minutes (120 seconds) **Resolution:** 1920x1080 @ 60fps **Format:** Animated mathematical visualization with synchronized voiceover

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## Tools & Technologies

Tool	Purpose
<b>Manim</b>	Mathematical animation engine for creating precise visualizations
<b>manim-voiceover</b>	Synchronized text-to-speech narration integration
<b>gTTS</b>	Google Text-to-Speech service for voiceover generation
<b>Python 3.14</b>	Core programming language with strict type checking
<b>NumPy</b>	Data generation for regression visualizations
<b>Nix + direnv</b>	Reproducible development environment
<b>Pyright</b>	Static type checking (strict mode)
<b>Ruff</b>	Code linting and formatting

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## Teaching Strategy

Our pedagogical approach follows a **Problem → Naive Solution → Theory** structure:

### 1. Problem: The Hallucination (Section 1)

We open with AI generating incoherent output—“The moon is made of blue algorithm potato...”—establishing that **intelligence without measurement is chaos**. This creates cognitive dissonance and motivates the need for evaluation.

### 2. Naive Solution: Binary Judgment (Section 2)

We introduce the concept of scoring but emphasize that **simple yes/no classification is insufficient**. A sliding gauge demonstrates continuous scoring (0.99

for correct answers, -0.50 for incorrect), leading to the definition: *Regression predicts a quantity.*

### 3. Theory: Linear & Non-Linear Regression (Sections 3-4)

- **Linear Regression:** Study hours vs. test scores—a perfect world where  $y = mx + b$  minimizes error (residuals)
- **Non-Linear Regression:** Drug dosage vs. patient health—demonstrating why **reality curves** and linear models fail on biological data

### 4. Synthesis (Section 5)

The curved regression line transforms into a single neuron, then reveals a neural network—showing that **AI judges are millions of non-linear regressions stacked together.**

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## Project Architecture

### Directory Structure

```
Manim-ML/
  src/
    config.py          # Central configuration (colors, timing, constants)
    utils/
      color_utils.py  # Color manipulation helpers
      data_generator.py # Reproducible regression data (seed=42)
  videos/
    scenes/           # 5 scene modules + complete composition
      section1_hallucination.py
      section2_scale.py
      section3_linear.py
      section4_nonlinear.py
      section5_synthesis.py
      judge_curve_complete.py # Main composition
    templates/
      animations.py    # Reusable animation functions
      effects.py       # Visual effects (glow, chromatic aberration)
      custom_shapes.py # Custom Manim mobjects
  media/             # Generated output (git-ignored)
```

### Manim Architecture Patterns

1. **VoiceoverScene Base Class** All scenes extend `VoiceoverScene` from `manim-voiceover`, enabling synchronized narration:

```

class LinearRegressionScene(VoiceoverScene):
    def construct(self) -> None:
        self.set_speech_service(GTTSService())
        with self.voiceover(text=self.VOICEOVER_TEXT) as tracker:
            self.play(Create(graph), run_time=tracker.duration)

```

**2. Centralized Configuration** Single source of truth in `src/config.py` using frozen dataclasses:

- `ColorPalette`: Consistent hex colors across all scenes
- `TimingConfig`: Animation duration categories (FAST/MEDIUM/SLOW)
- `SceneConfig`: Precise timing boundaries (start/end timestamps)

**3. Composable Scene Rendering** The `JudgeCurveComplete` class orchestrates all 5 sections by calling each scene's `render_animations()` method, passing the parent scene context for seamless transitions.

**4. Reproducible Data Generation** NumPy-based data generators use a fixed seed (`DATA_SEED = 42`) ensuring identical scatter plots across renders:

- `generate_linear_data()`: Upward-trending points for Section 3
- `generate_nonlinear_data()`: Dose-response curves for Section 4

**5. Reusable Effects Library** `videos/templates/effects.py` provides visual effects:

- `apply_chromatic_aberration()`: RGB-split distortion effect
- `apply_glow_effect()`: Neon glow for emphasis
- `create_static_noise_overlay()`: TV static for hallucination scene

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## Script Overview

Section	Time	Visual Content	Voiceover Theme
<b>1. Hallucination</b>	0:00-0:25	Terminal chaos, “NO METRIC FOUND” warning, static	AI without judgment produces noise
<b>2. Continuous Scale</b>	0:25-0:50	Split-screen comparison, reward slider	Regression predicts a quantity
<b>3. Linear Regression</b>	0:50-1:15	Scatter plot, best-fit line, residuals	Minimize error with $y = mx + b$
<b>4. Non-Linear</b>	1:15-1:40	Dose-response curve, linear failure, polynomial	Reality curves, we bend the math
<b>5. Synthesis</b>	1:40-2:00	Curve→neuron→network transformation	Neural networks = stacked regressions

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## Team Members

Member	GitHub	Contributions
<b>Enrique</b>	@Enriquefft	Script writing, voiceover production, codebase architecture & setup
<b>Joaquin Arriaga</b>	@joaquinarriaga-ui	Section 1 (Hallucination) & Section 2 (Continuous Scale)
<b>Renato</b>	@jfloredev	Section 3 (Linear Regression) & Section 4 (Non-Linear Regression)

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## Final Video

Watch the video

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