Rationalizing YouTube Commenting behavior

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YouTube $>$ 1 billion users. 300 hours of content created every minute.

- How to model, predict user engagement?
  How do thumbnail, title, description of video affect popularity?
  How does interaction of YouTube channels with users affect popularity? User $\rightarrow$ Video Content $\rightarrow$ User
- *Why?* Content Caching in 5G. Recommender systems, Strategic Design for content producers (e.g. BBTV).
- *Main Result*: Based on massive YouTube dataset, Bayesian Revealed Preferences with Deep Embedded Clustering yields accurate model that relates viewcount to commenting behavior.

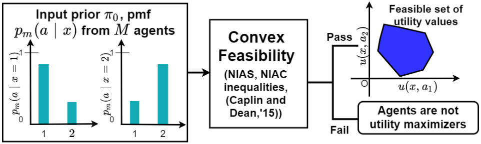
YouTube Commenting as Bayesian Utility Maximization

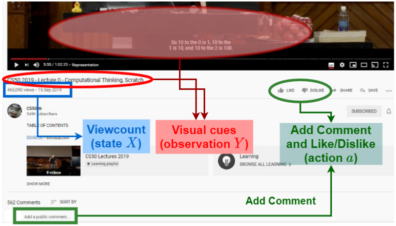
State: $X \in \{\text{low viewcount}, \text{high viewcount}\}$, $X \sim \pi_0$ (prior)
Observation: $Y \sim \alpha(y|x)$. Visual cues from thumbnail, video description
Attention function of viewer: α
Action: a. Comment count (high or low), sentiment (positive, negative or neutral)
Commenter's reputation: $u(x, a)$
Rational Inattention Cost: $C(\alpha, \pi_0)$

Optimize commenting behavior:

$$(\alpha^*, a^*) \in \arg\max_{\alpha, a} \mathbb{E}_{\pi_0,\alpha}\{u(X, a(Y))\} - C(\pi_0, \alpha)$$

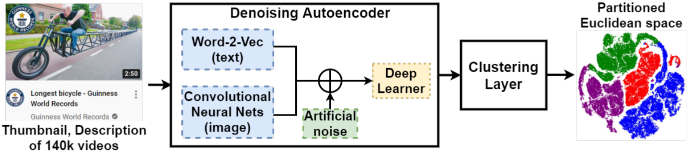
Analyst aim: Given $\pi_0, \{p_m(a|x), m \in \mathcal{M}\}$ from M agents, detect utility maximization.





Massive dataset: 140k videos, 25k channels.
Dimension Reduction. *How to group videos of specific topic with similar commenting behavior?*
(i) *User-centric*: Deep Clustering using thumbnail & description.
(ii) *Content-centric*: Video category.
Main Result: YouTube commenting is consistent with utility maximization. Estimated utility can predict commenting behavior. (83% accuracy).

Deep Embedded Clustering and Dataset Analysis



Autoencoder partitions YouTube dataset into 8 distinct clusters (agents).

How well does Bayesian Utility Maximization explain dataset?

General Rational Inattention cost: All 8 clusters satisfy test.

Renyi/Shannon mutual information cost: 2/8 clusters satisfy test.

Finer Granularity. 18 categories using topic (Gaming, Politics, Education, etc.)

Result: 10 categories satisfy general cost, 2 categories satisfy Renyi/Shannon.

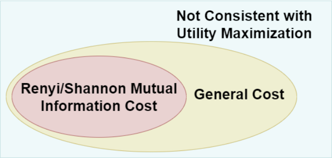
Key Insights:

- Clusters fail Renyi/Shannon by small margin $\Longrightarrow$ model is robust.
- Utility (reputation) is substantially higher for popular videos.
- *Predictive Accuracy*. Given a video in a specific category, predicts comment count with 83% accuracy; sentiment with 80% accuracy.

Robustness of utility maximization test

Quantifying robustness:

- For categories that satisfy utility maximization, how far are they from failing.
- For categories that don't satisfy, how close are they to passing.



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1. **For categories that fail general cost,** find min. perturbation to pass.

Result: **Average** $\epsilon_1 = 1.2 \times 10^{-3}$.

2. **For categories that satisfy general cost,** find max. perturbation to fail.

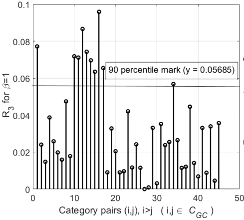
Result: **Average** $\epsilon_2 = 7.01 \times 10^{-3}$.

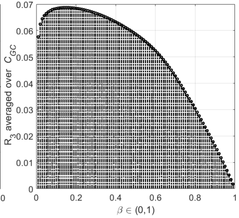
Conclusion: $\epsilon_1 / \epsilon_2 \approx 6$, hence categories are much closer to satisfying general cost than failing.

3. **For categories that satisfy general cost,** find min. perturbation to satisfy Renyi or Shannon cost.

Renyi Entropy: $H_\beta(p) = \sum_{i=1}^{n} \log(p_i^\beta)/(1-\beta)$.

Shannon cost: Renyi cost with $\beta \to 1$.





Extensions and Limitations

- *Sequential Information sampling*: How to incorporate the visual cues of the viewer while watching the video into the attention function?
- *Temporal dependence of commenting behavior:* How to incorporate the effect of existing comments on a video on future comments and commenter reputation? Herding and information cascades.
- *Analyzing effect of changing meta-features:* How to detect a change in commenter reputation if the thumbnail/description is modified after the video is posted?
- *Feedback Control:* How to adapt video title & keywords to maximize view count given knowledge of commenter reputation?
- *Richer models of commenting reputation:* The five dominant meta-level features that affect the popularity of a video are: first day view count, number of subscribers, contrast of the video thumbnail, Google hits, and number of keywords. How do all these features affect commenting behavior?