ATRIA: Adaptive Streaming of 360-Degree Videos with Reinforcement Learning

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Introduction

Problem Statement:
- Significant interests in streaming immersive multimedia content.
- Amount of video data to be downloaded is large.
- A viewer views only a small portion (viewport) at time.
- Viewport-adaptive tiled streaming for 360-degree must run a complex optimization in real-time in the presence of multiple uncertainties (e.g., network conditions / user behavior).

Preivous Works:
- Existing solutions attempts to solve this using simplified rules.
- Flare (MobiCom '18), Mosaic (IFIP '19), DRL360 (InfoCom '19)

Challenges:
- No 'labeled data'. NW condition x User Behavior x Video => Qi
- Large State / Action Space when using Reinforcement Learning.
- Delayed rewards: Need to wait complete download of tiles of a segment.

Contributions

> ATRIA (Adaptive sTreaming using ReInforcement leArning)

*** Determines sequentially the tile and tile quality to download**

*** Maximizes the user quality of experience given network constraints**

*** Uses A3C to learn a streaming policy that**

*** Addresses RL challenges (large state/action space, delayed reward)**

> ATRIA can adapt well on uncertainties (user behavior / network condition).

> ATRIA can generalize well on unseen videos and it is unnecessary to train ATRIA on any specific video.

> Comprehensive evaluations show that ATRIA outperforms the state-of-the-art techniques. ITU-T P.910 based subjective user studies further confirm the superiority of our approach.

System Design

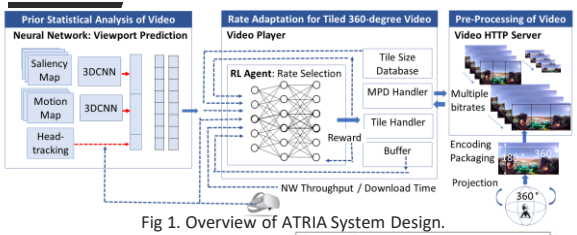


Fig 1. Overview of ATRIA System Design.

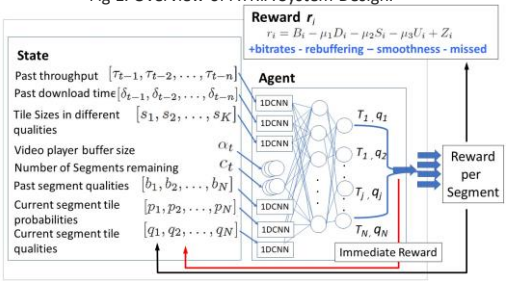


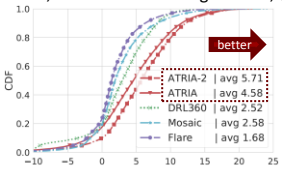
Fig. 2. High level network architecture of ATRIA.

(a) **ATRIA**: Adaptive tile ordering (b) **ATRIA-2**: Fixed tile ordering

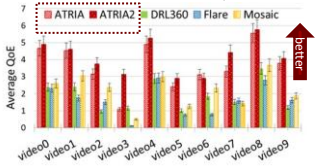
Fig. 3. Design Approaches. The first nine tiles and their qualities selected. **(a)** ATRIA: The agent selects the tile and their download quality for each action. **(b)** ATRIA-2: At each step, the tile to download is already determined. The agent determines the tile quality to download.

Experimental Results

10 videos, each with head tracking data of 50 users, 270 Network Traces.
135,000 Video Streaming Session, (≈ 2,250 hours, over 3 months).



(a) Average QoE



(b) QoE for streaming different videos.

(c) Coaster with ATRIA-2

(d) Coaster with DRL360

Fig 4. **(a)-(b)**. Comparison of QoE of ATRIA / ATRIA-2 with other baseline techniques. **(b)** Only video0 is used for training ATRIA/ATRIA-2. **(c)-(d)**: Frame captures of video session for a video with ATRIA-2 and DRL360. **(d)** shows poor image quality (yellow rectangle areas) for DRL360.

Conclusion

- Previous 360-degree video streaming techniques do not adapt well to changing viewport and network conditions.
- ATRIA uses 3DCNN model to predict the viewport and applies a RL based adaptive streaming approach.
- Comprehensive evaluations with real network traces shows that ATRIA outperforms the state-of-the-art techniques.
- **Published in** the Proceeding of IEEE/CVF Winter Conference on Applications of Computer Vision, 2021 (WACV' 21).