Recurrent and Dynamic Models for Predicting Streaming Video Quality of Experience

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Overview

- In streaming video applications, the opinion of the human viewer is the gold standard. In these applications, Quality of Experience (QoE) is the measure of the overall level of customer satisfaction with a service.

- In streaming, there are two major types of video impairments: compression/scaling artifacts and re-buffering.

- We designed dynamic approaches to predict subjective, continuous-time video quality of experience due to these impairments.

Previous Works

- Only study retrospective quality of experience or compression vs. re-buffering events in isolation.

- Do not exploit time-series ensemble forecasts and model selection is very simple.

This Work

- Subjective QoE is a non-linear aggregate of video quality, rebuffering information and memory.

- Capture these features as external variables.

- Multiple forecasts should be combined to obtain robust forecasts when monitoring QoE in real-world video streaming environments.

Visual Examples

Distorted Videos

- Non-linear autoregressive with exogenous variables (NARX) model:

$$y_t = f(y_{t-1}, y_{t-2}, ..., y_{t-d_y}, \mathbf{u}_t, \mathbf{u}_{t-1}, \mathbf{u}_{t-2}, ..., \mathbf{u}_{t-d_u})$$

$\{\mathbf{u}_t, \mathbf{u}_{t-1}, \mathbf{u}_{t-2}, ..., \mathbf{u}_{t-d_u}\}$: previous (and current) external variables
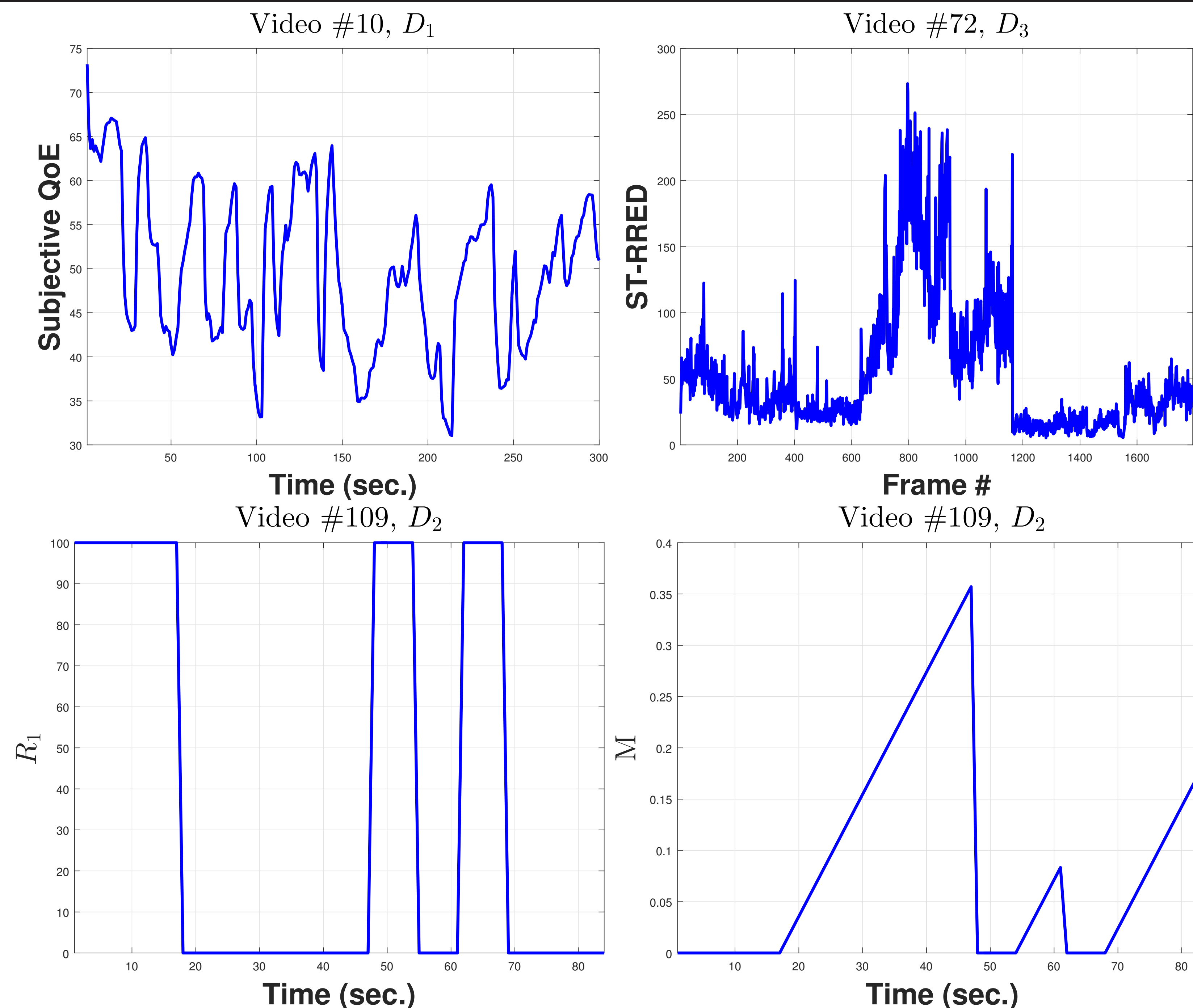$\{y_{t-1}, y_{t-2}, ..., y_{t-d_y}\}$: previous inputs
$f(\cdot)$: non-linear function
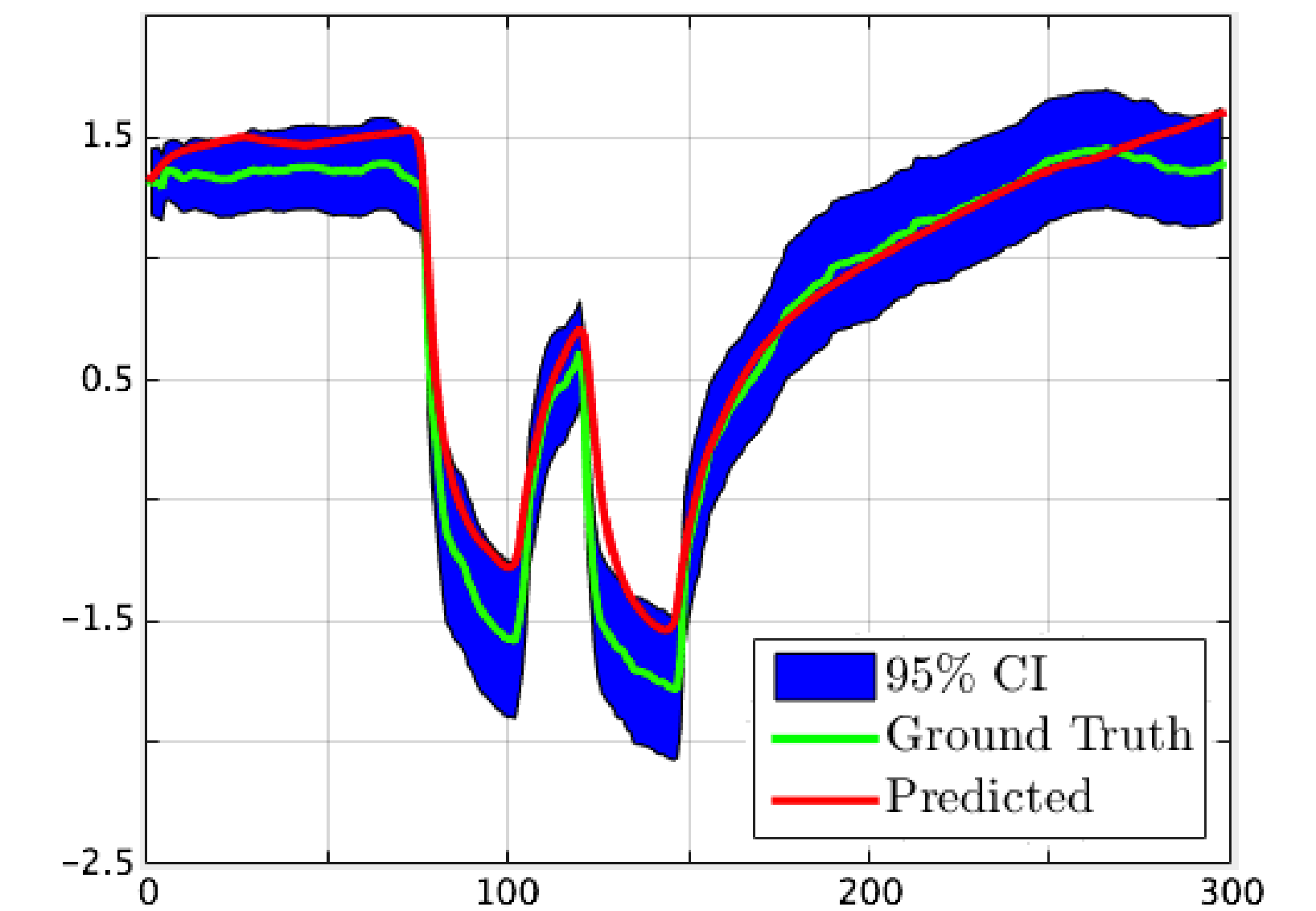d_y: number of lags in the input
d_u: number of lags in the external variables

- External variables: ST-RRED to measure quality, a boolean step function for re-buffering (R_1) and a linear variable for the time since most recent rebuffering (M).

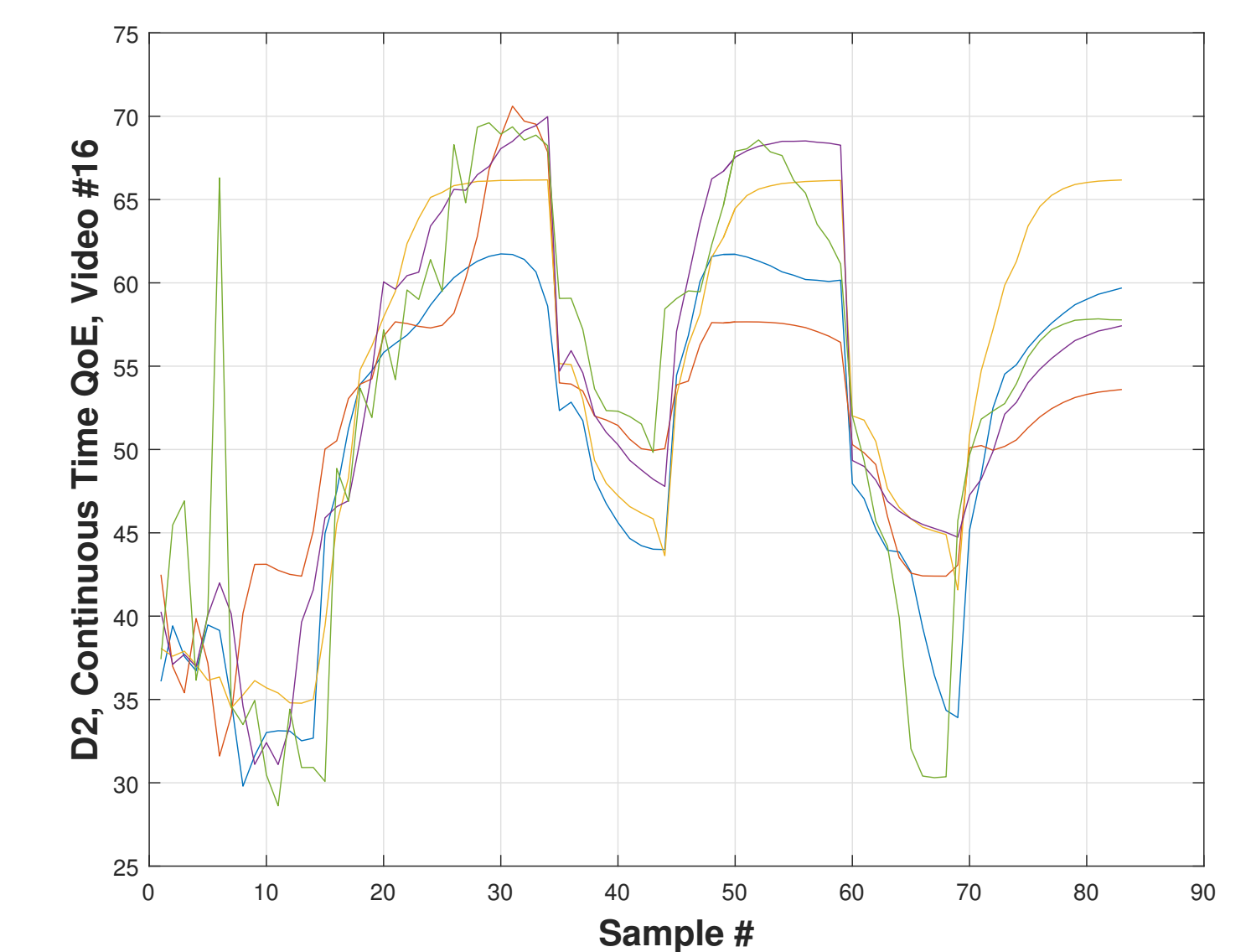**Ground Truth and Example External Variables on Different Datasets**

Example Output

Extensive Experiments

- Augment with ensemble forecasts: reduces prediction variance and improves prediction.

- Also test recurrent neural networks and Hammerstein-Wiener models on multiple QoE subjective datasets.

Future work

- Integrate continuous-time predictions to perceptually optimize adaptive streaming decisions.