Tile rate selection for 360 Video Streaming to Head-Mounted Displays

Associate professor:
Andrea Zanella

Student:
Luca Attanasio

Date:
14/02/2019

Advisor:
Federico Chiariotti

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

360 VR streaming

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Initial context

- 360 videos are intensive bandwidth
- Fetching the entire frame wastes bandwidth
- Higher quality is required compared to 2D counterparts
- **Problem**: how should quality be assigned to tiles in order to maximize the QoE?
- **Solution**: tiled streaming with SRD (Spatial Representation Description) and head movement prediction.

Head Mounted Displays

System Architecture

Results

QoE analysis

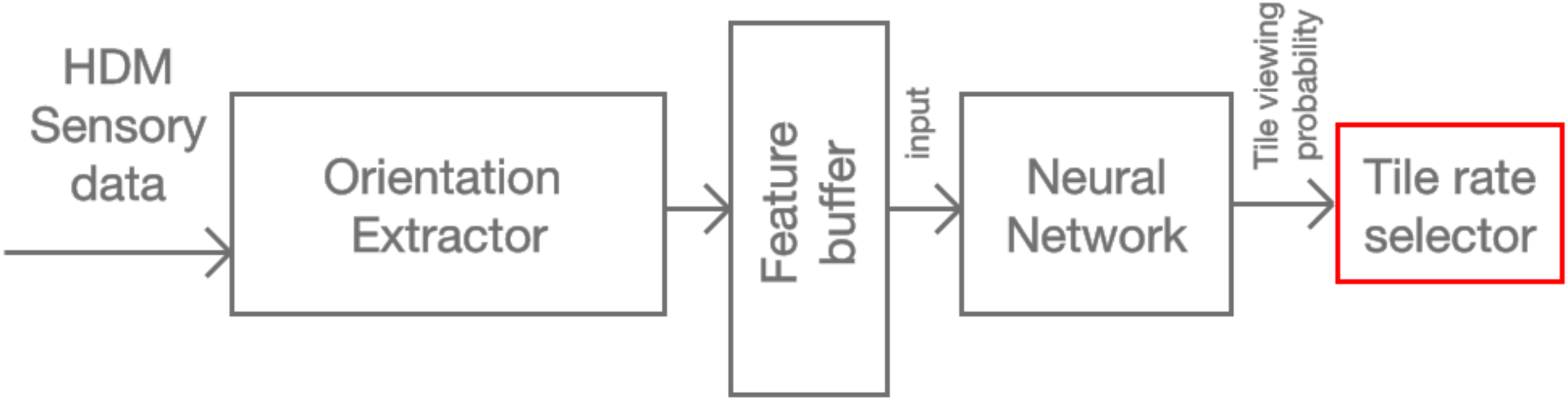
DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Head Mounted Displays (HMD)

- 70$ billion are expected to be spent on HMD by 2020
- HMD have a fixed FoV (i.e. 110 degrees)
- Orientations can be captured in about 50ms

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

System architecture



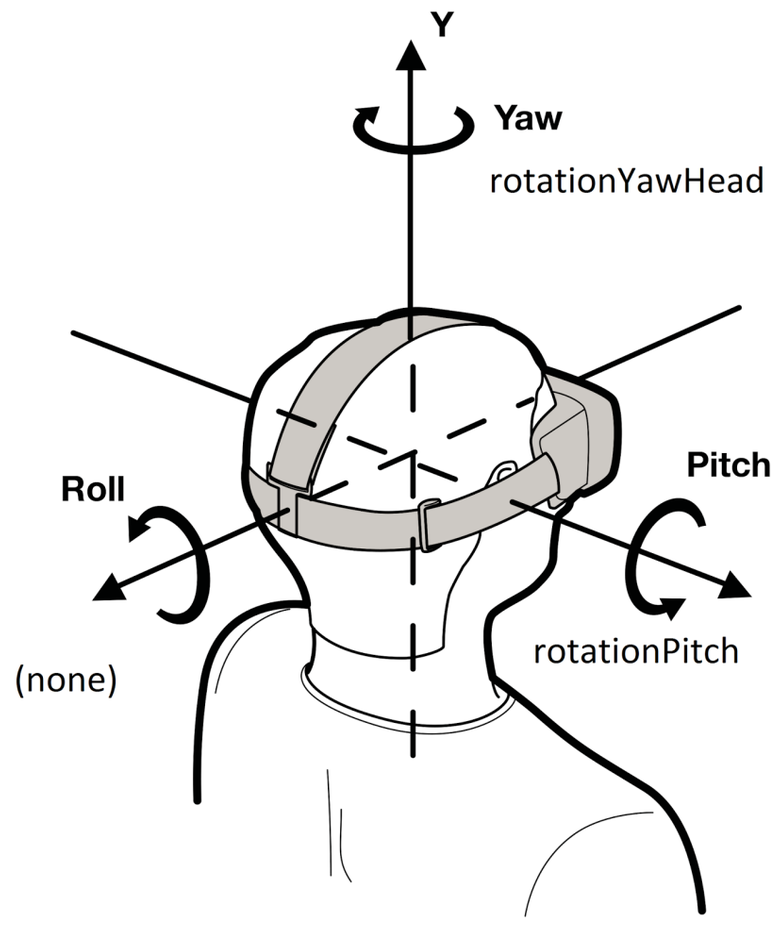
DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Neural network details

- Public dataset (quaternions) used to train the neural network in a supervised learning approach
- 512 neurons x 1 layer
- Errors: Training 21.91%, Testing 29.58%, Validation 24.01%
- input: 5 consecutive orientations, output: tiles probability at 0.5s distance in the future
- output: tile's viewing probability

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Equirectangular equations

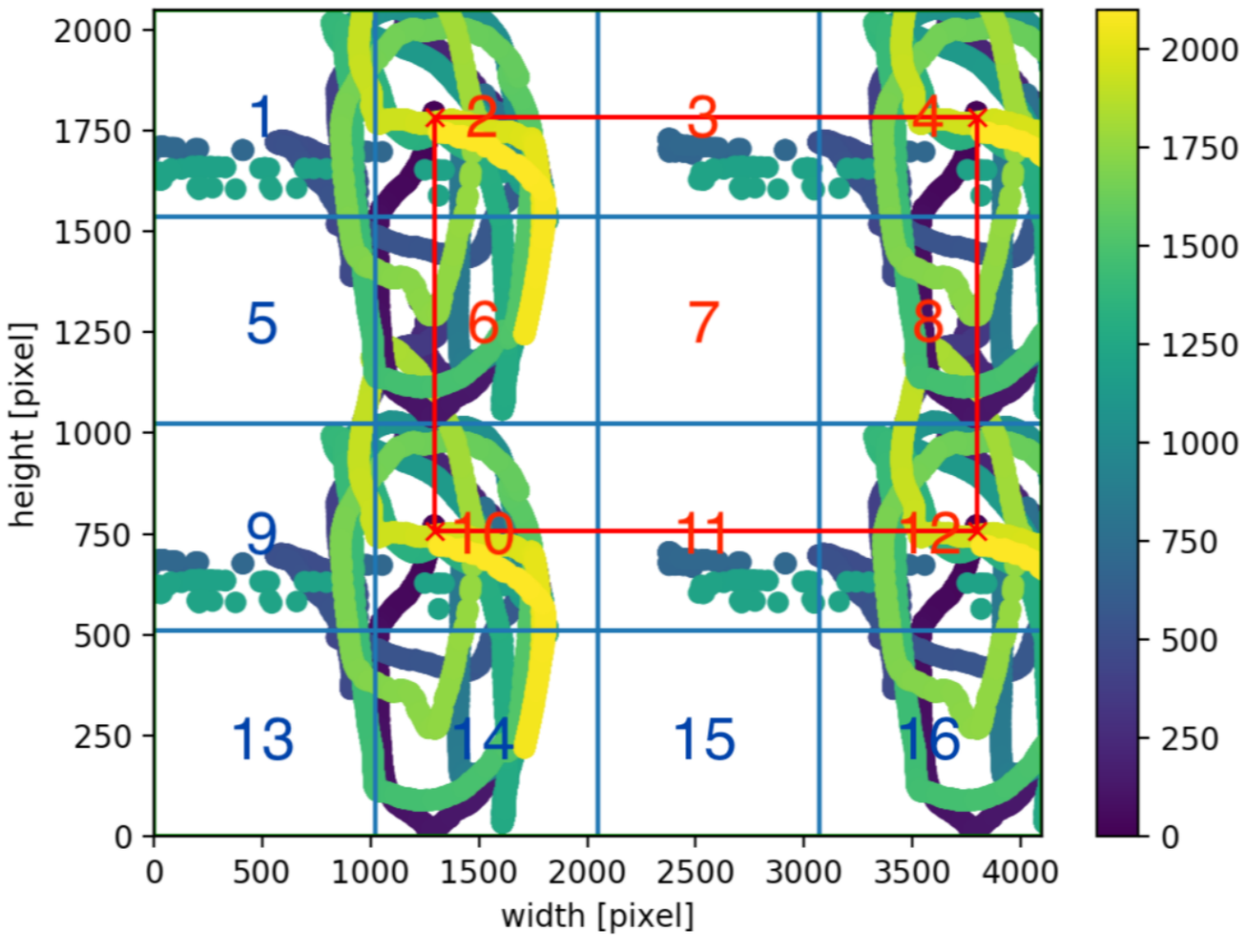


- True viewing tiles are computed using equirectangular projection

$$x = \frac{yaw + 180°}{360°} w \qquad y = \frac{(90° - pitch)}{180°} h \qquad (1)$$

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Tiles prediction



DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Tile rate selector

Rule

$$\arg\max \sum_{j=1}^{n}\sum_{i=1}^{m} q_{i,j}p_{i,j} \leq \sum_{j=1}^{n}\sum_{i=1}^{m} q'_{i,j}p'_{i,j} \tag{2}$$

Cumulative probability

$$c_j = \sum_{i=1}^{m} p_{i,j} \tag{3}$$

Assigned Bandwidth

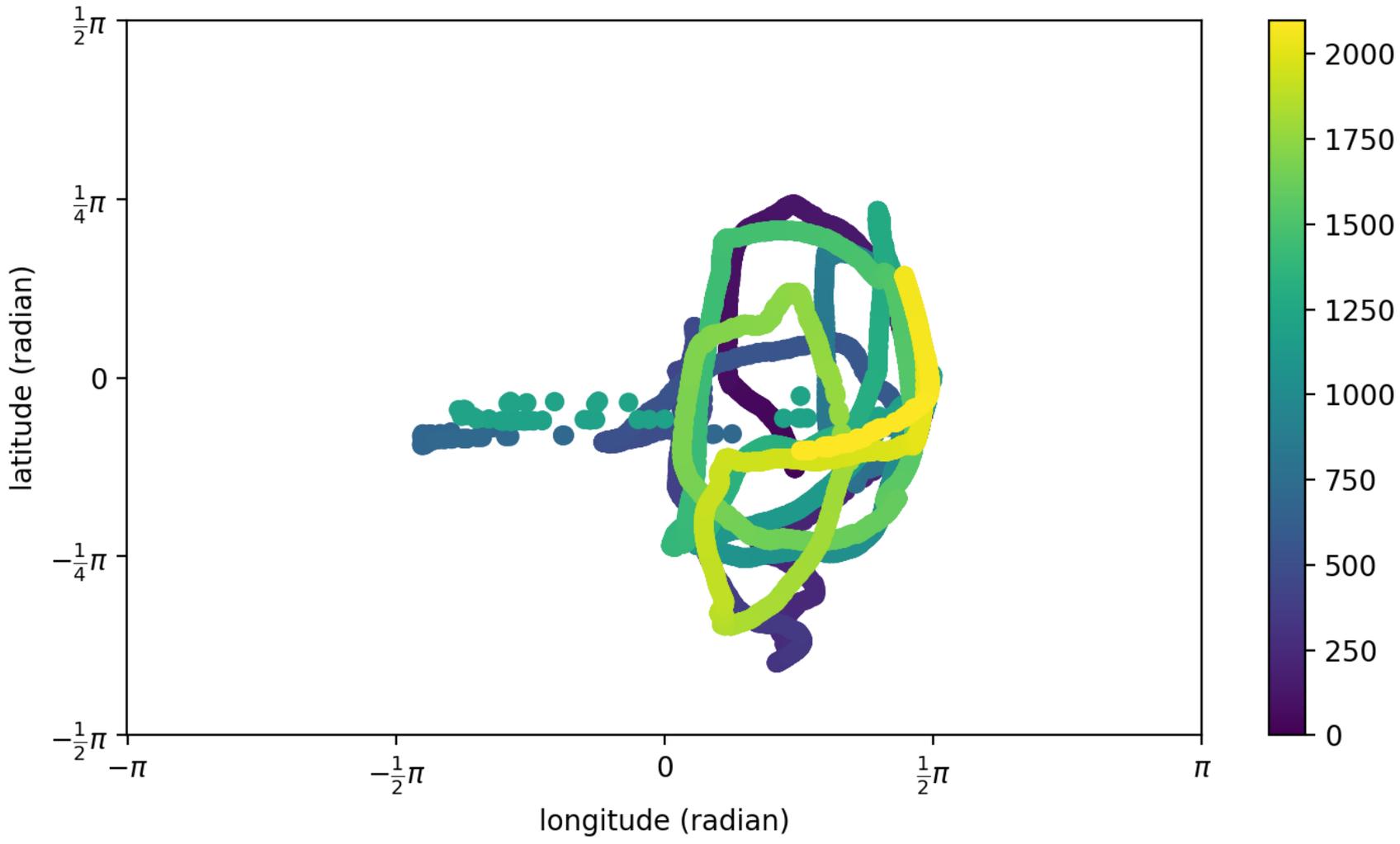
$$b_{i,j} = \frac{p_{i,j}}{c_j} b_j \tag{4}$$

Bandwidth mapping

$$\vec{b}^R = [5800, 4300, 3750, 3000, 2350, 1750, 110]$$

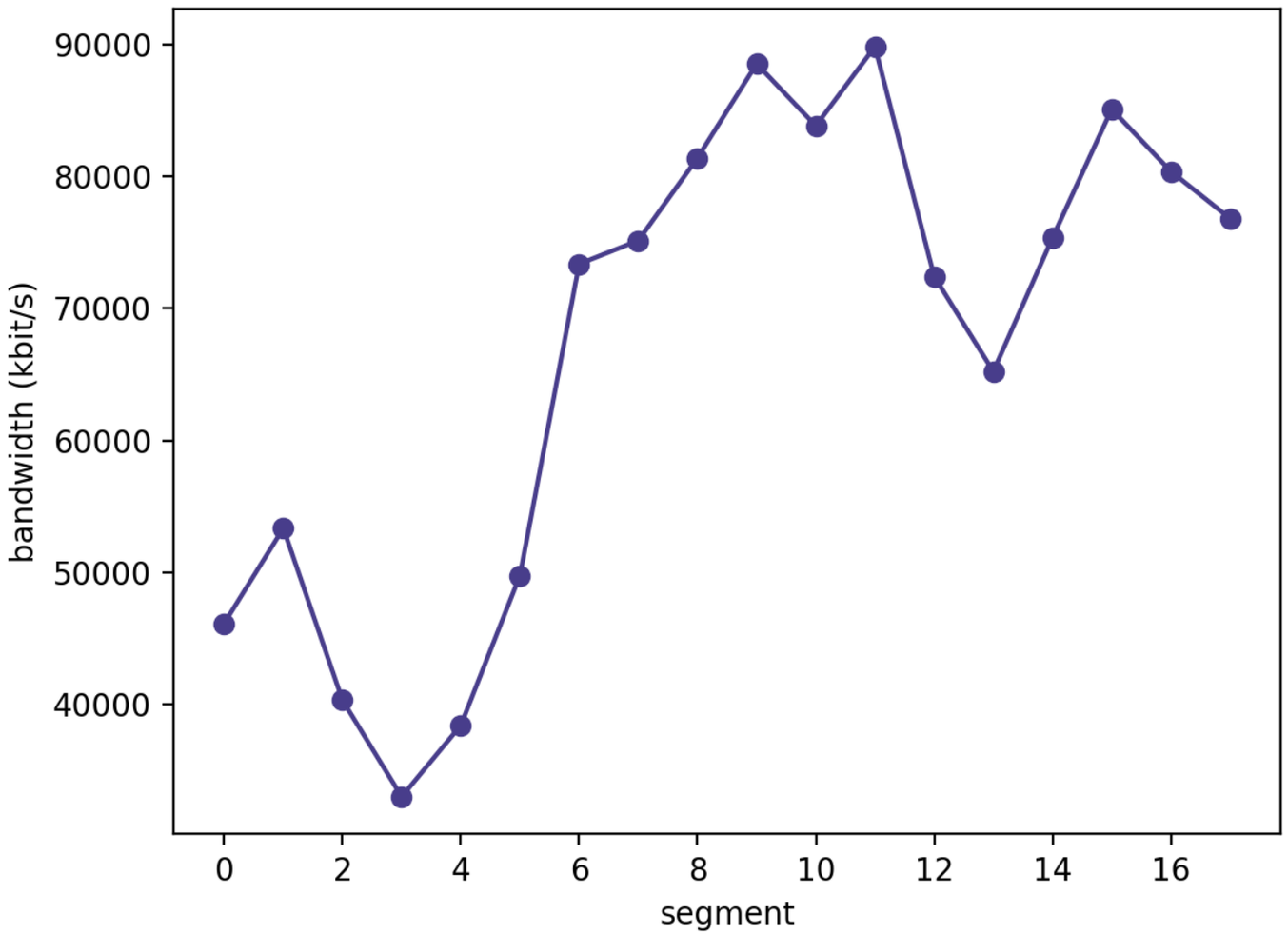
DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Results: head movements



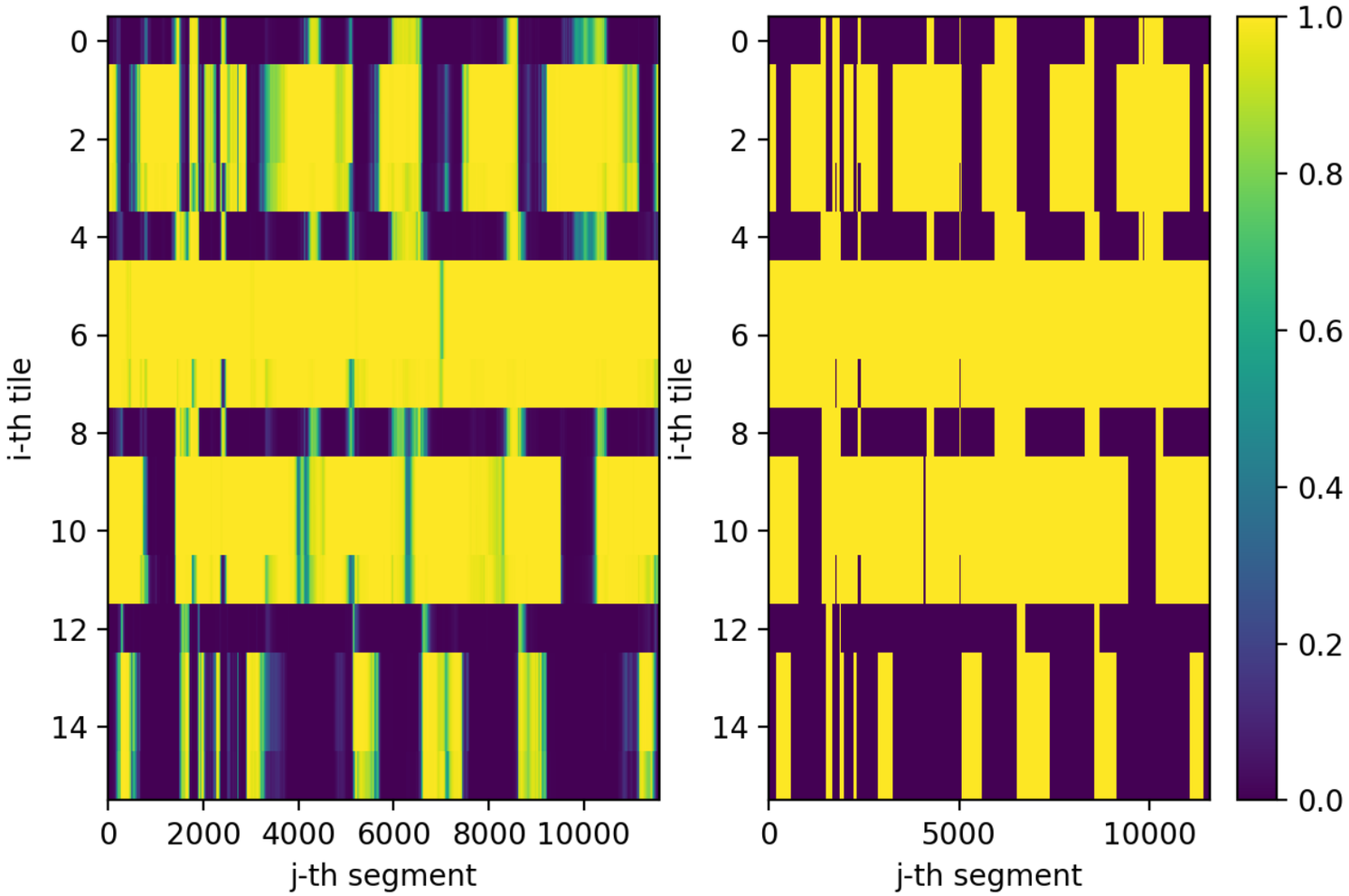
DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Assigned bandwidth



DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Probability



DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

QoE analysis

Quality

Quality variations

DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

QoE computation

Quality

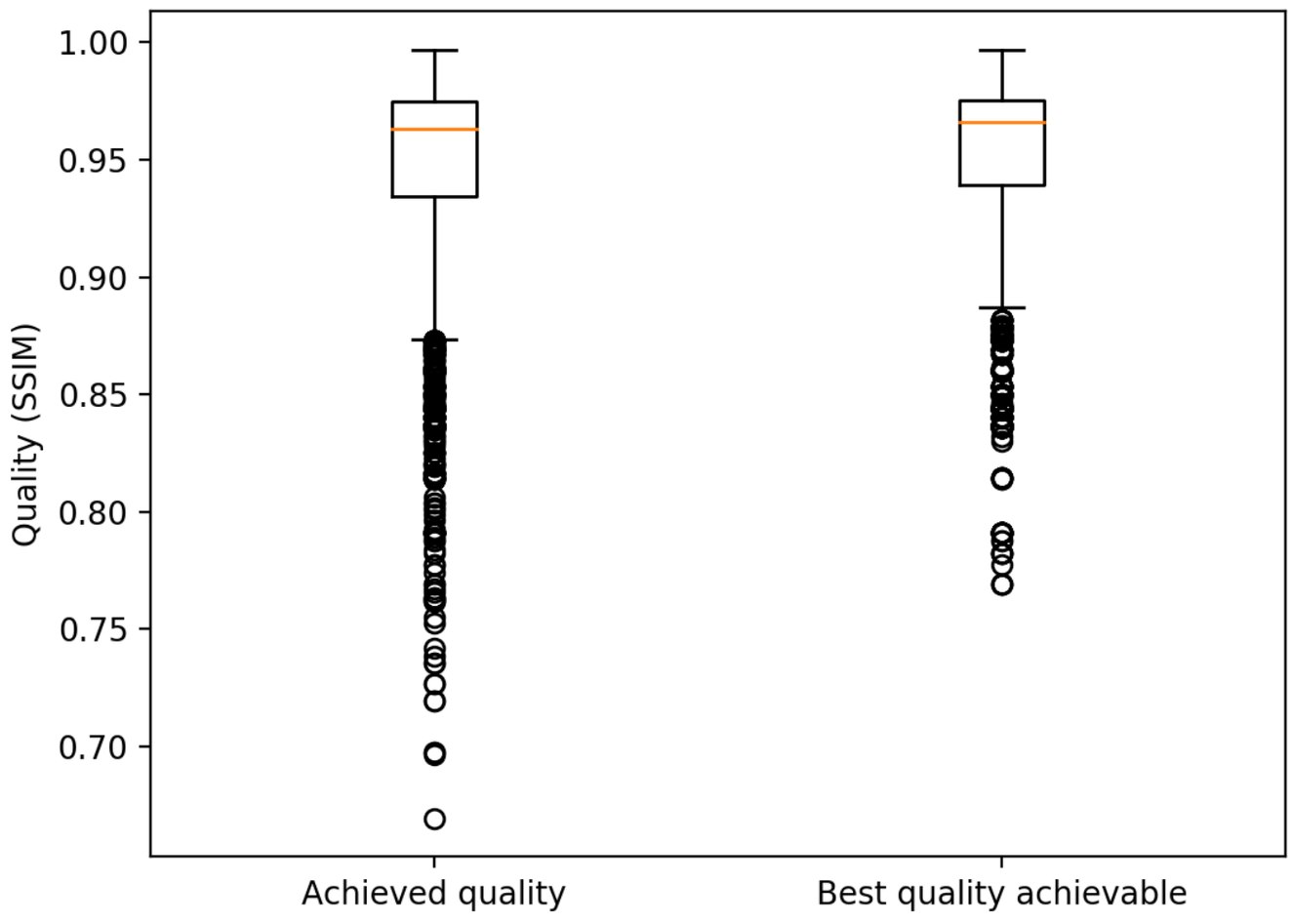
$$q = \sum_{j=1}^{n} \sum_{i=1}^{m} q_{i,j} \leq q' = \sum_{j=1}^{n} \sum_{i=1}^{m} q'_{i,j} \tag{5}$$

Quality variations

$$\Delta q_j = \sum_{i=1}^{m} [q_{i,j} \times p'_{i,j} - q_{i,j+1} \times p'_{i,j+1}] \tag{6}$$

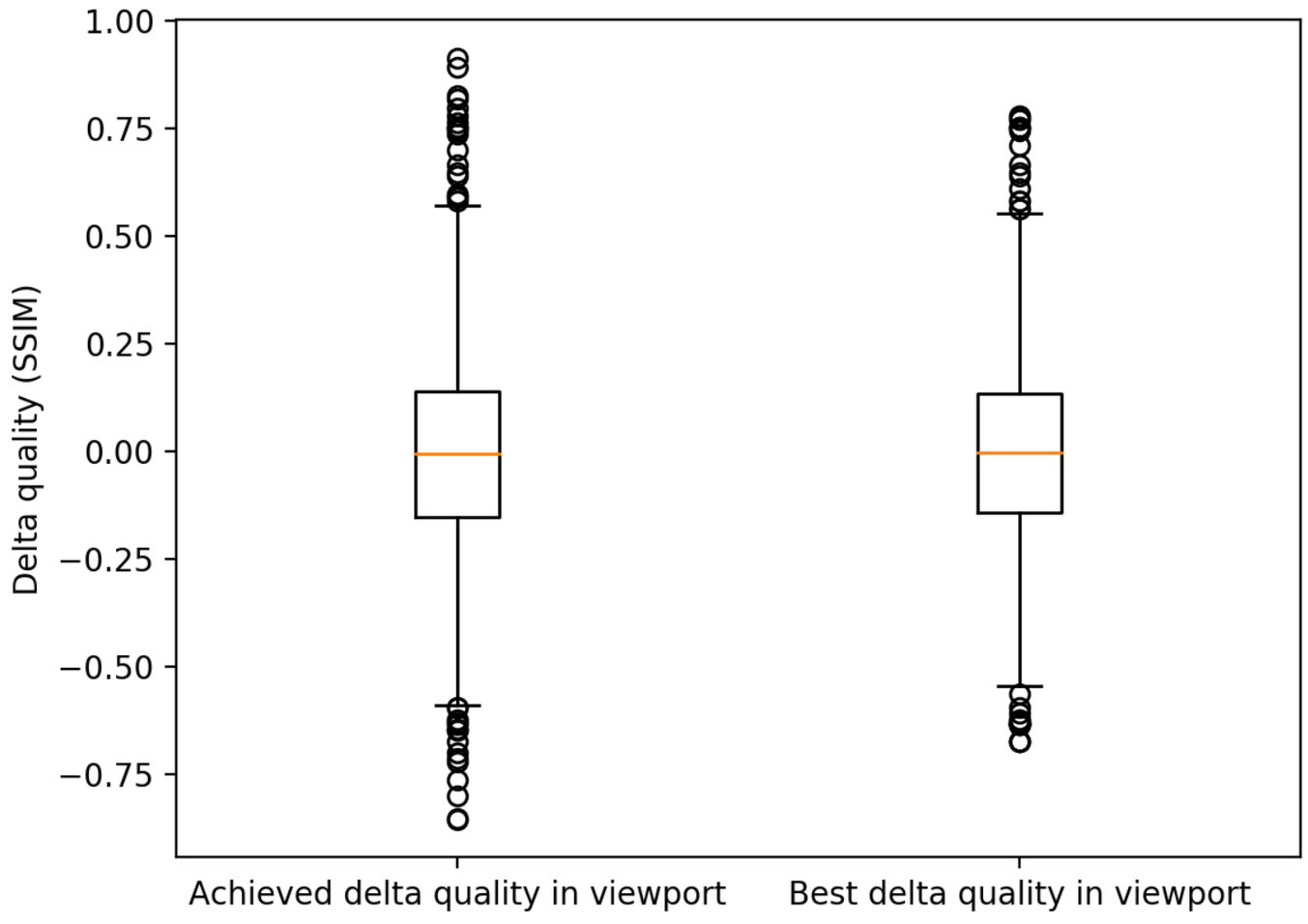
DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Quality



DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Quality variations



DIPARTIMENTO
DI INGEGNERIA
DELL'INFORMAZIONE

Conclusions

- Tile rate selection is is highly dependent on NN tiles' probability prediction
- High quality videos can be delivered if predicting tiles in 0.5s
- The tile rate selector analyzed maximizes the QoE
- Future work: further training and testing of the neural network using different videos and SSIM