An ANFIS-based Hybrid Video Quality Prediction Model for Video Streaming over Wireless Networks

ADAMANTIUM

Information & Communication Technologies

COOPERATION

Asiya Khan, Lingfen Sun & Emmanuel Ifeachor

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University of Plymouth
United Kingdom

{asiya.khan; l.sun; e.ifeachor} @plymouth.ac.uk

Presentation Outline

- Background
  - Video quality for wireless networks
  - Current status
  - Aims of the project
- Main Contributions
  - Classification of video content into three main categories
  - Impact of application and network level parameters on video quality
  - Novel non-intrusive video quality prediction models based on ANFIS in terms of MOS score and Q value[3]
- Conclusions and Future Work

Background – Video Quality for Wireless Networks(1)

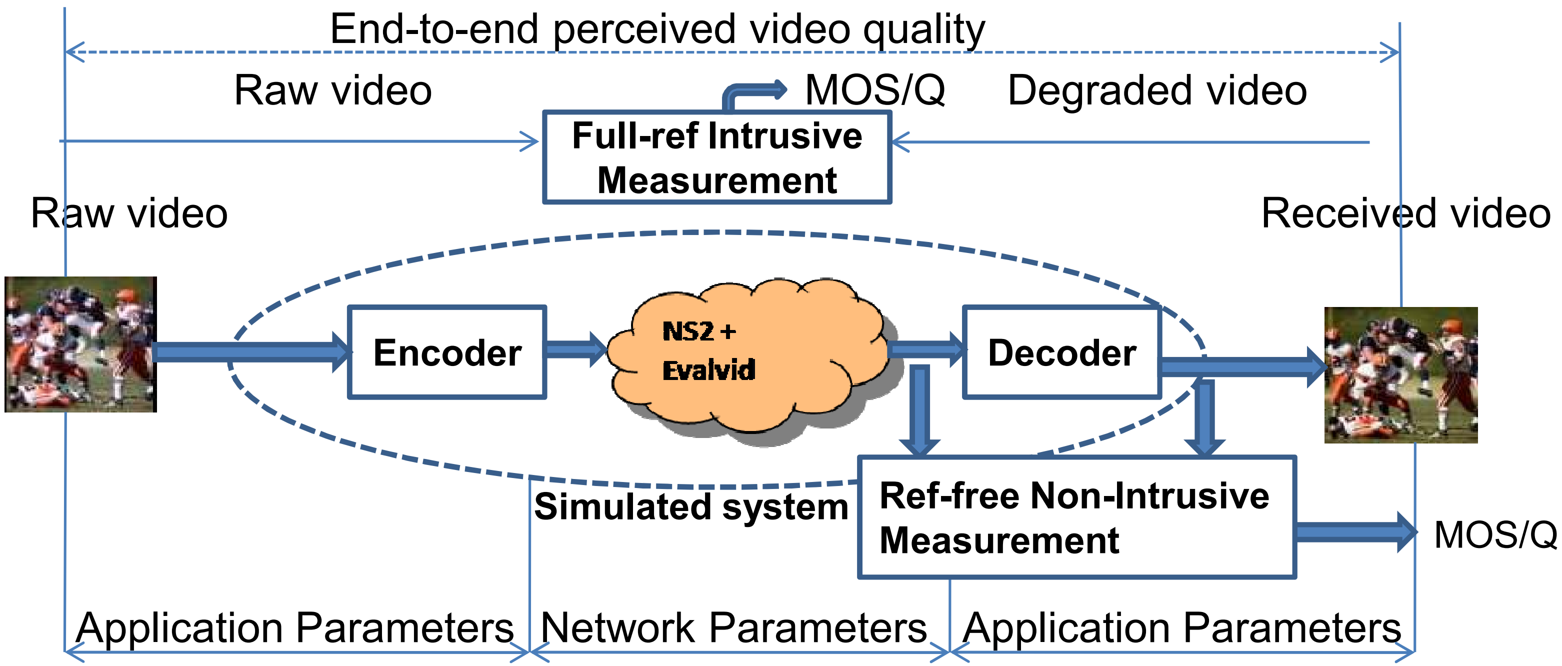
Video Quality Measurement

- Subjective method (Mean Opinion Score -- MOS)
- Objective methods
  - Intrusive methods (e.g. PSNR, Q value[3])
  - Non-intrusive methods (e.g. ANN-based models)

Why do we need to predict video quality?

- Multimedia services are increasingly accessed with wireless components
- For Quality of Service (QoS) control for multimedia applications

Background – Video Quality for Wireless Networks(2)



- Video quality: end-user perceived quality (MOS), an important metric.
- Affected by application and network level and other impairments.
- Video quality measurement: subjective (MOS) or objective (intrusive or non-intrusive)

Current Status and Motivations(1)

- Lack of an efficient non-intrusive video quality measurement method
- Current video quality prediction methods mainly based on application level or network level parameters
- Neural network based models not widely used for video quality prediction.
  - NN models based on application parameters and content characteristics but NOT considered network parameters **OR**
  - NN models based on application and network parameters without considering content types

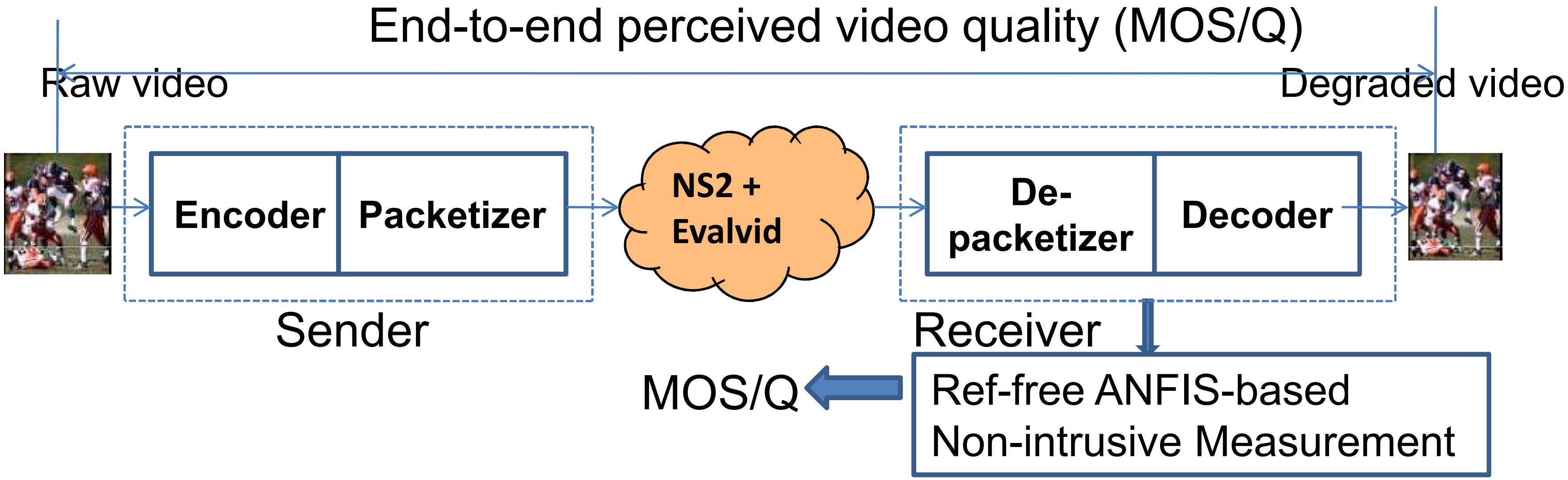
Current Status and Motivations(2)

- NN databases are mainly based on subjective tests
- As subjective test is time consuming, costly and stringent, available databases are limited and cannot cover all the possible scenarios
- Only a limited number of subjects attended MOS tests
- **Proposed test bed is based on NS2 with an integrated tool Evalvid[4] – as it gives a lot of flexibility for evaluating different topologies and parameter settings used.**

Current Status and Motivations(3)

- Content adaptation is a ***hot*** topic and is suited to neural network model as ANNs can learn from content change.
- Why use ANFIS-based Artificial Neural Networks(ANN)?
  - Video quality is affected by many parameters and their relationship is thought to be non-linear
  - ANN can learn this non-linear relationship
  - Fuzzy systems are similar to human reasoning(not just 0 or 1)
  - ANFIS(Adaptive Neural-Fuzzy Inference System) combines the advantages of neural networks and fuzzy systems

Aims of the Project



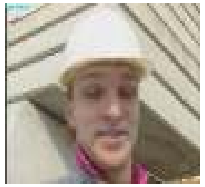
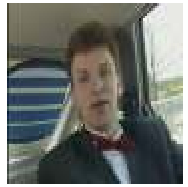
- Classification of video content into three main categories
- Impact of application and network level parameters on video quality using objective measurement.
- Novel non-intrusive video quality prediction models based on ANFIS in terms of MOS score and Q value[3]

Classification of Video Contents

<u>Test Sequences Classified into 3 Categories of:</u>

1. Slow Movement(SM) – video clip ‘Akiyo’ for *training* and ‘Suzie’ for *validation*.


2. Gentle Walking(GW) – video clip ‘Foreman’ for *training* and ‘Carphone’ for *validation*.

3. Rapid Movement(RM) – video clip ‘Stefan’ for *training* and ‘Rugby’ for *validation*.


All video sequences were in the qcif format (176 x 144), encoded with MPEG4 video codec [6]

List of Variable Test Parameters

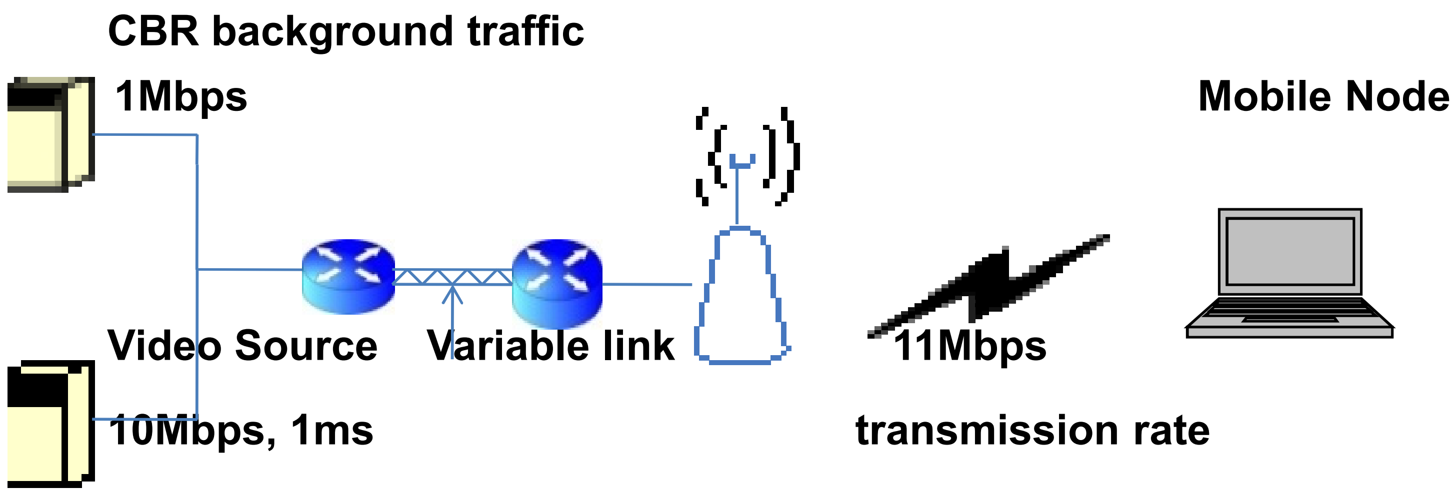
- Application Level Parameters:
  - Frame Rate **FR** (10, 15, 30fps)
  - Send Bitrate **SBR** (18, 44, 80kb/s for SM & GW; 80, 104, 512kb/s for RM)
- Network Level Parameters:
  - Packet Error Rate **PER** (0.01, 0.05, 0.1, 0.15, 0.2)
  - Link Bandwidth **LBW** (32, 64, 128kb/s for SM; 128, 256, 384kb/s for GW; 384, 512, 768, 1000kb/s for RM)

Testbed Combinations

Video sequence	Frame Rate (fps)	SBR (kb/s)	Link BW (kb/s)	PER
Slight Movement	10, 15, 30	18	32, 64, 128	0.01, 0.05, 0.1, 0.15, 0.2
	10, 15, 30	44		
	10, 15, 30	80		
Gentle Walking	10, 15, 30	18	128, 256, 384	0.01, 0.05, 0.1, 0.15, 0.2
	10, 15, 30	44		
	10, 15, 30	80		
Rapid Movement	10, 15, 30	80	384, 512, 768, 1000	0.01, 0.05, 0.1, 0.15, 0.2
	10, 15, 30	104		
	10, 15, 30	512		

Parameters values are typical of video streaming over 3G to WLAN applications

Simulation set-up



- All experiments conducted with open source Evalvid[4] and NS2[5]

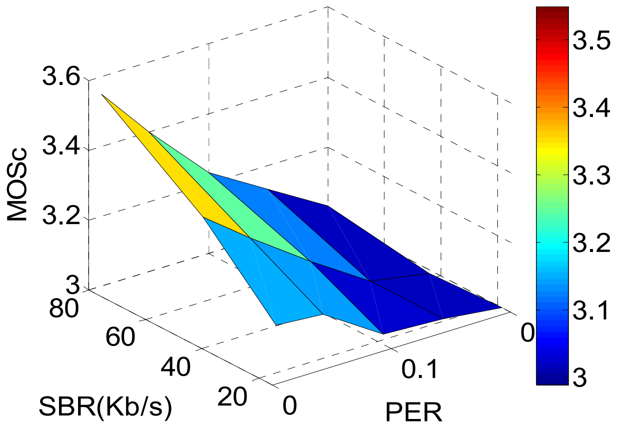
Simulation Platform

- Video quality measured by taking average PSNR over all the decoded frames.
- MOS scores calculated from conversion from Evalvid[4].
- Q[3] obtained from the same testing combinations.

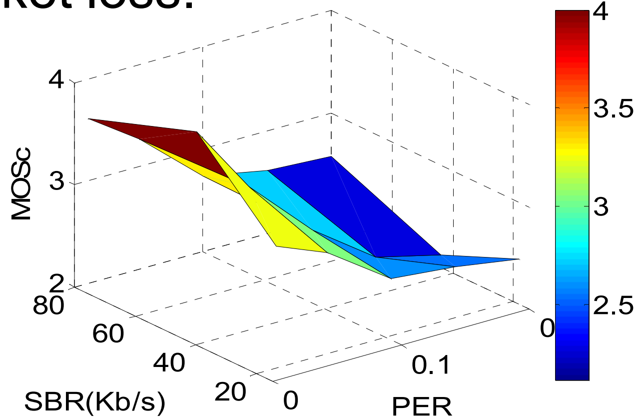
PSNR(dB)	MOS
> 37	5
31 – 36.9	4
25 – 30.9	3
20 – 24.9	2
< 19.9	1

Impact of Application & Network Level Parameters on Video Quality(1)

MOS vs Send Bitrate vs Packet error rate for SM, GW



Video quality of GW fades very rapidly with higher packet loss(acceptable upto ~ 8%) Increasing the SBR does not compensate for higher packet loss.

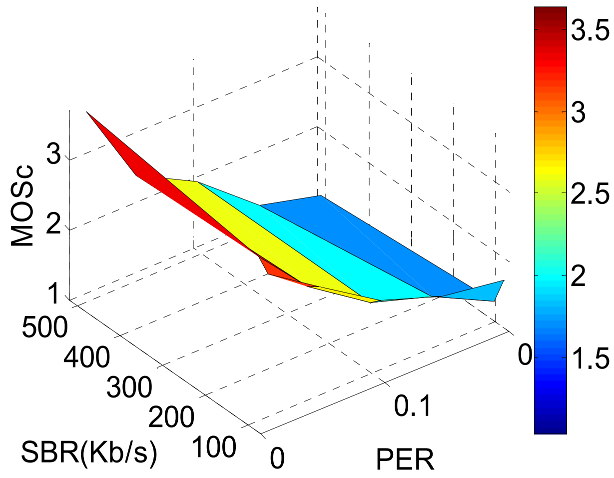


Video quality for SM acceptable upto packet loss of 20%(MOS>3.5)

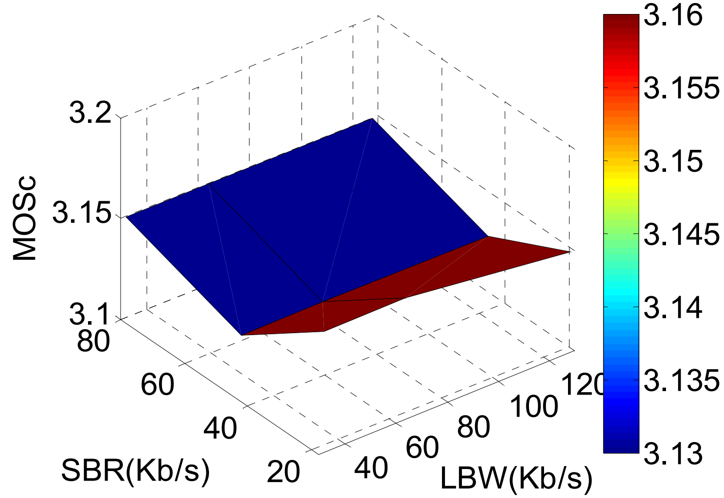
Impact of Application & Network Level Parameters on Video Quality(2)

MOS vs SBR vs PER for RM

Video quality for RM is similar to GW acceptable ~ 5% packet loss



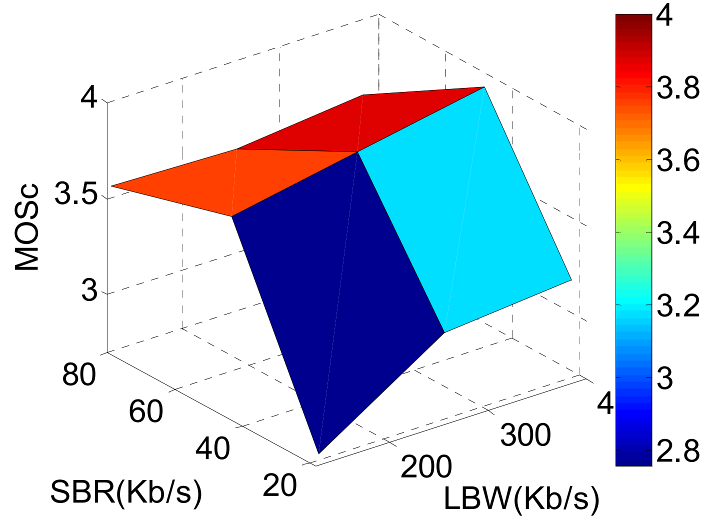
MOS vs SBR vs LBW for SM



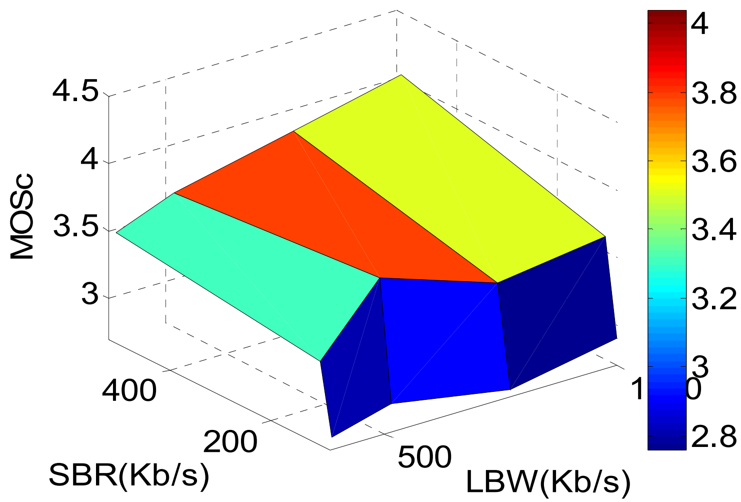
Increasing the LBW as expected improves the video quality. Also if the SBR > LBW due then video quality Worsens due to network congestion.

Impact of Application & Network Level Parameters on Video Quality(3)

MOS vs SBR vs LBW for GW & RM



GW

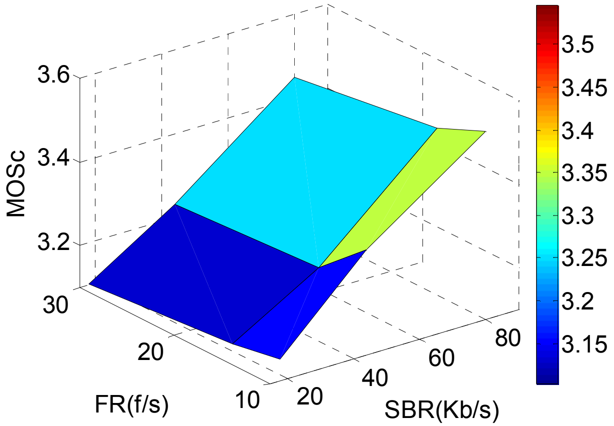


RM

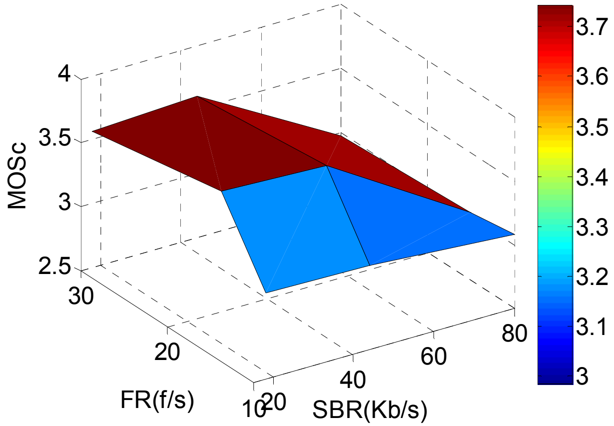
Same as SM

Impact of Application & Network Level Parameters on Video Quality(4)

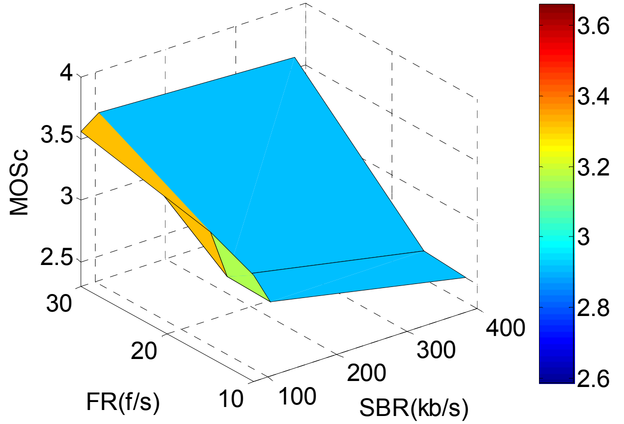
MOS vs FR vs SBR for SM, GW & RM



SM



GW



RM

Increasing the frame rate increases the video quality upto 15fps

Impact of Application & Network Level Parameters on Video Quality(5)

Impact of SBR and FR

- SBR exhibits a great influence on quality.
- Increasing the SBR increases the video quality.
- However it does not compensate for higher packet loss.
- Content category of SM very low SBR of 18kb/s gives acceptable video quality (MOS > 3.5) for communication standards
- FR is not as significant as SBR.
- Improvement of quality for FR greater than 15fps is negligible

Impact of PER and LBW

- Quality reduces drastically with the increase of PER
- Increase in LBW will only improve video quality if SBR is less than the LBW due to network congestion problems. The effect of LBW is generally measured in terms of packet error rate or delay.

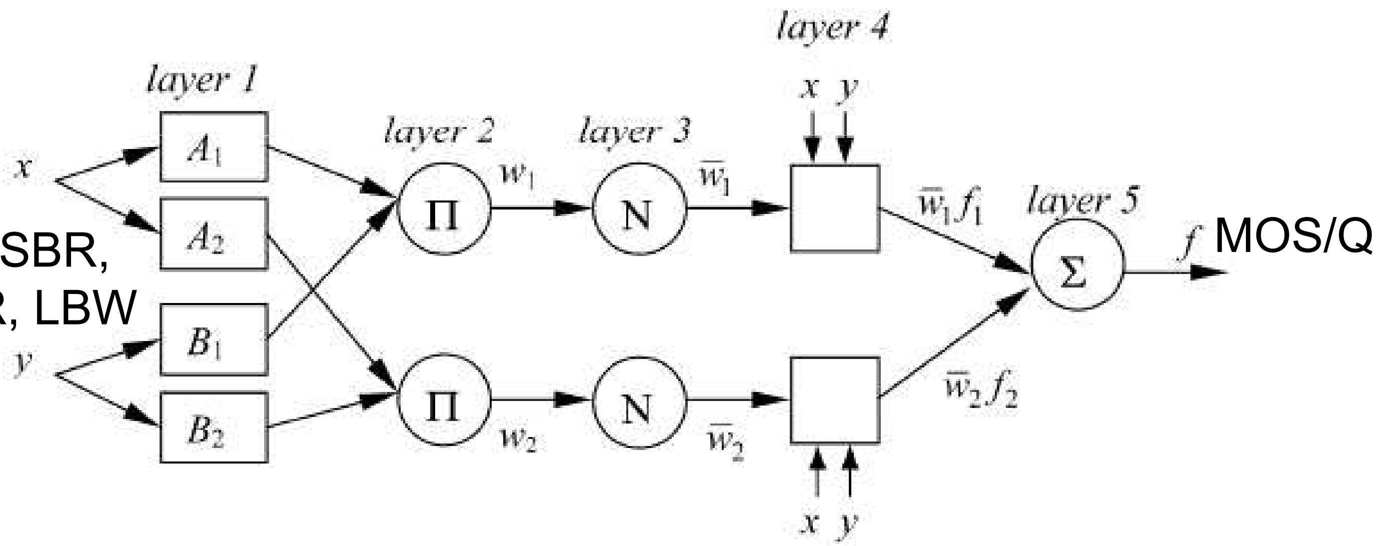
Non-intrusive Video Quality Prediction Models based on ANFIS(1)

- Developed an ANFIS-based artificial neural network model (using MATLAB).
- Identified four variables as inputs to ANFIS-based ANN
  - Frame rate
  - Send bitrate
  - Packet error rate
  - Link bandwidth
- Two outputs (MOS and Q value[3])
- Q value[3] (the decodable frame rate) is a relatively new application level metric and is defined as the number of decodable frames over the total number of frames sent by video source.

Novel Non-intrusive Video Quality Prediction Models based on ANFIS(2)

ANFIS-based ANN Architecture

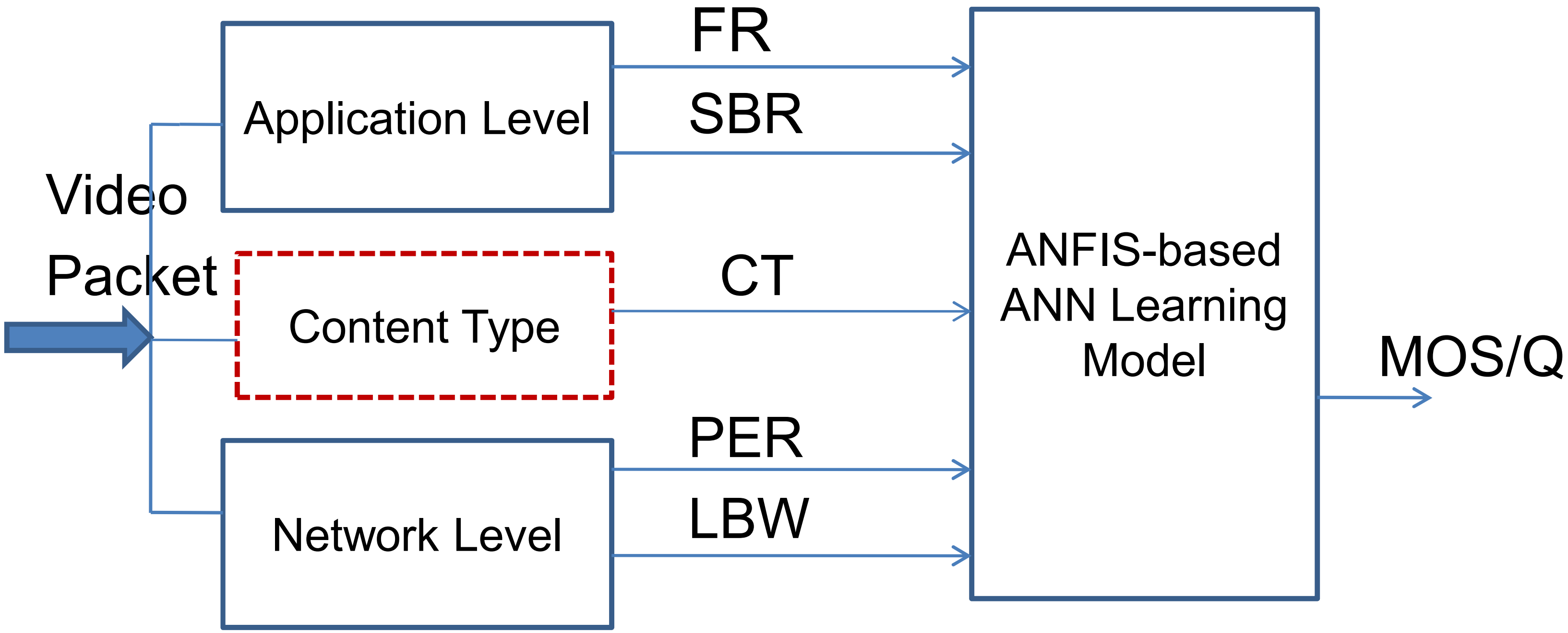
FR, SBR,
PER, LBW



The entire system architecture consists of five layers, namely, a fuzzy layer, a product layer, a normalized layer, a defuzzy layer and a total output layer.

Novel Non-intrusive Video Quality Prediction Models based on ANFIS(3)

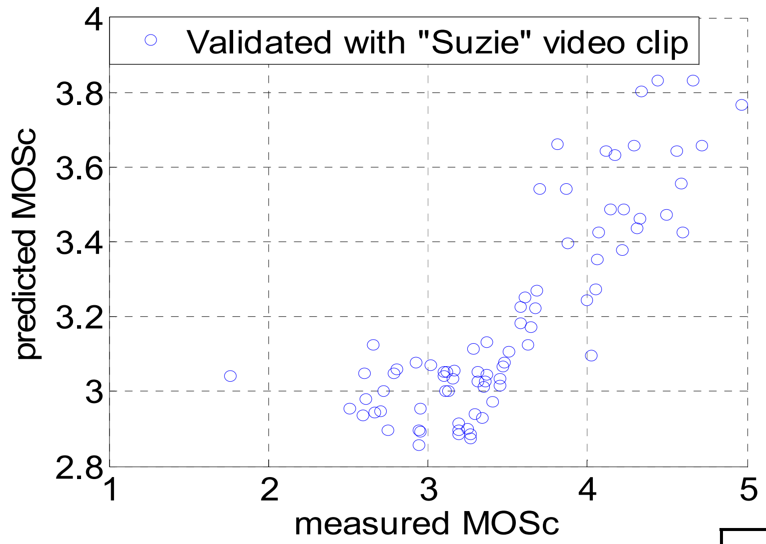
ANFIS-based ANN Learning Model

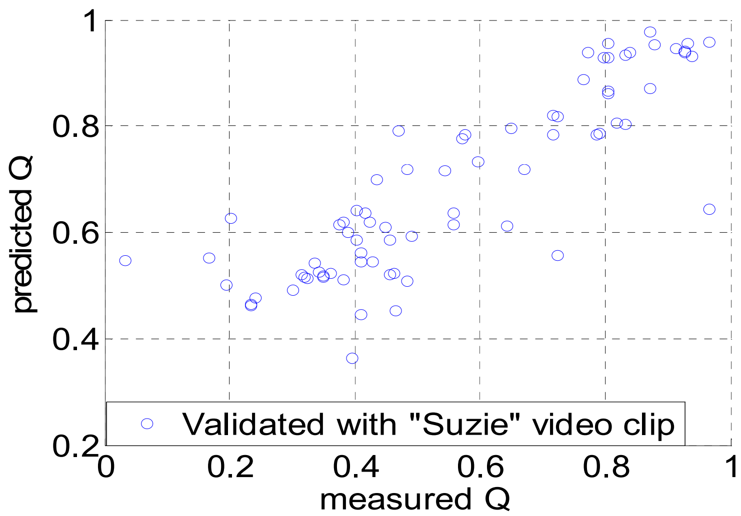


A total of 450 samples (patterns) were generated based on Evalvid[4] as the training set and 210 samples as the validation dataset for the 3 CTs.

Novel Non-intrusive Video Quality Prediction Models based on ANFIS(4)

Evaluation of the ANFIS-based Learning Model for SM



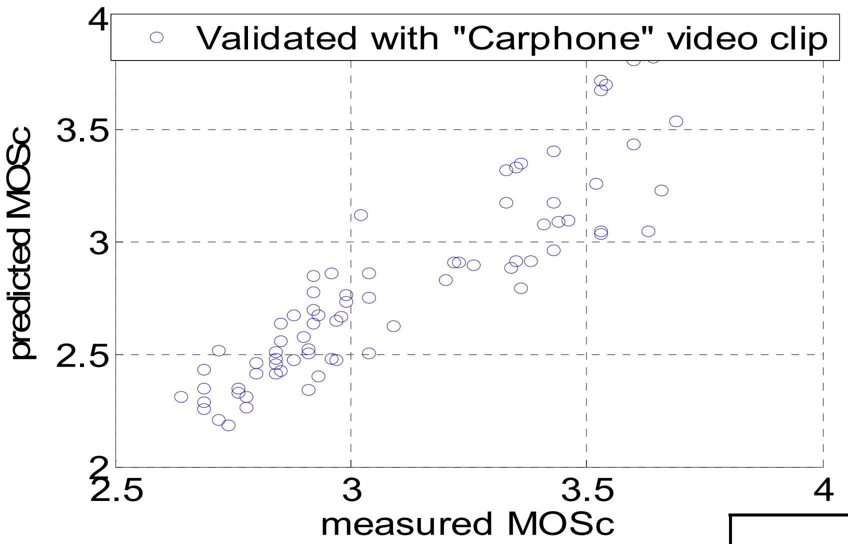


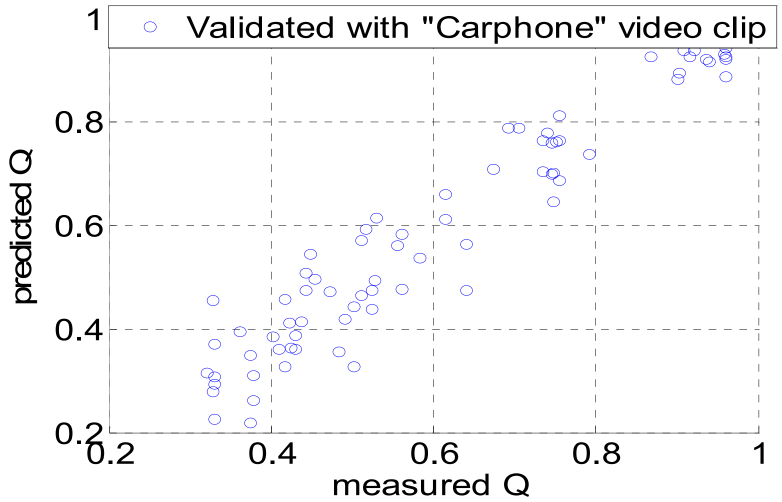
$$MOS/Q_{pred} = a_1 MOS/Q_{measured} + b_1$$

	R^2	RMSE	a1	a2
MOS	0.7007	0.1545	0.3696	1.8999
Q	0.7384	0.08813	0.6241	0.3359

Novel Non-intrusive Video Quality Prediction Models based on ANFIS(5)

Evaluation of the ANFIS-based Learning Model for GW



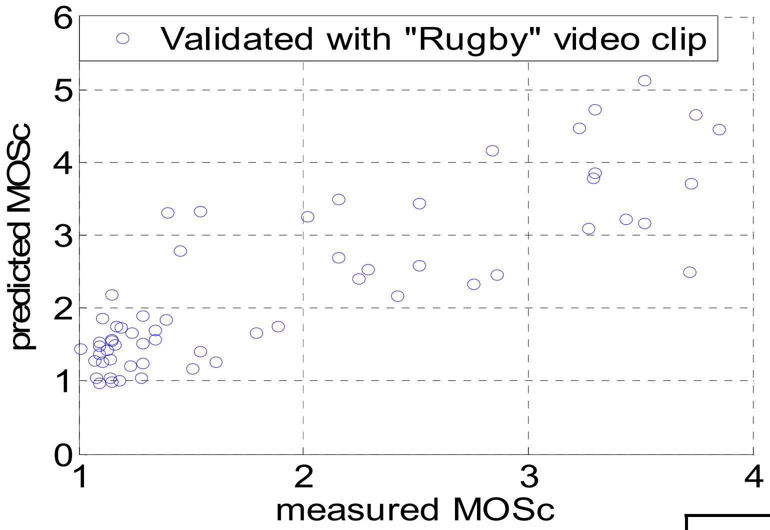


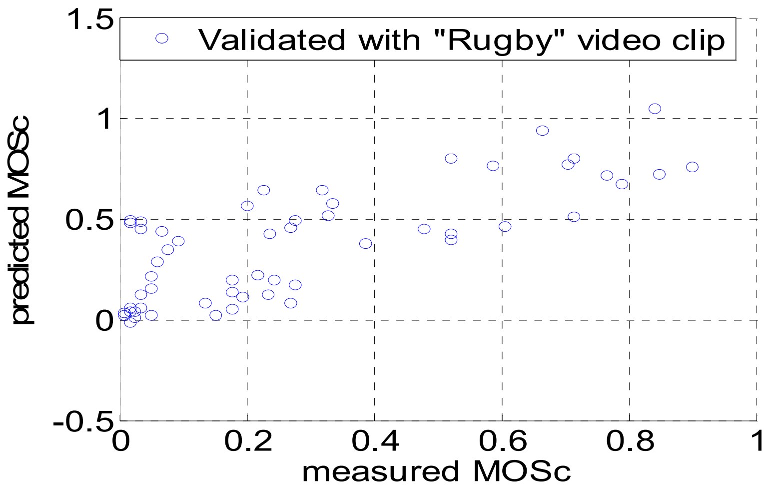
$$MOS/Q_{pred} = a_1 MOS/Q_{measured} + b_1$$

	R^2	RMSE	a1	a2
MOS	0.8056	0.1846	1.222	-0.9855
Q	0.9229	0.06234	1.032	-0.03716

Novel Non-intrusive Video Quality Prediction Models based on ANFIS(6)

Evaluation of the ANFIS-based Learning Model for RM





$$MOS/Q_{pred} = a_1 MOS/Q_{measured} + b_1$$

	R^2	RMSE	a1	a2
MOS	0.7034	0.6193	1.014	0.3247
Q	0.5845	0.1816	0.7898	0.1476

Novel Non-intrusive Video Quality Prediction Models based on ANFIS(7)

- Generated a validation dataset from different video clips in the three content types and different set of values for the four input parameters (total 210 samples).

- Obtained good prediction accuracy in terms of the correlation coefficient (R^2)and root mean error squared for the validation dataset using an ANFIS-based neural network.

This suggested that the ANFIS-based neural network model works well for video quality prediction in general.

Conclusions

- Classified the video content in three categories.
- Investigated and analyzed the combined effects of application and network parameters on end-to-end perceived video quality based on MOS and Q value[3].
- SBR and PER have a great impact on video quality. FR is not as significant and LBW is very difficult to measure.
- Based on the application and network level parameters successfully developed an ANFIS-based learning model to predict video quality for MPEG4 video streaming over wireless network application.

Future Work

- Classifying the video content objectively.
- Propose one model for all contents.
- Extend to Gilbert Eliot loss model.
- Use subjective data.
- Propose adaptation mechanisms for QoS control.

References

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Contact details

- http://www.tech.plymouth.ac.uk/spmc
- Asiya Khan *asiya.khan@plymouth.ac.uk*
- Dr Lingfen Sun *l.sun@plymouth.ac.uk*
- Prof Emmanuel Ifeachor *e.ifeachor@plymouth.ac.uk*
- http://www.ict-adamantium.eu/

- Any questions?

Thank you!