Developing an ANFIS-Based Model to Predict Web Services QoS/QoE

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ABSTRACT

- Some authors propose using the non-functional properties of Quality of Service (QoS) and user's needs of Quality of Experience (QoE) in planning WS quality.
  - QoS description is based on non-functional attributes (like response time, throughput, etc.) on the technological level – objective features. QoE attributes (like cost, reputation, etc.) are subjective characteristics obtained from the user's subjective evaluation of an item at a business level and depend on the morale, interests, and other subjective factors.
  - QoS attributes are expressed in a *numerical form* and can be used to determine QoS using data-driven prediction methods. QoE attributes – in a *non-numerical/linguistic form*.
- We propose a new hybrid fuzzy-based reasoning approach for predicting WS quality with the adaptive neuro-fuzzy inference system (ANFIS) suitable for processing numerical and linguistic data input.
- The proposed approach was implemented as a prototype, two experiments were conducted. The results of the experiments comparison show a good accuracy of the proposed approach for predicting WS quality. It is a suitable tool for predicting WS quality.

BACKGROUND (ANFIS)

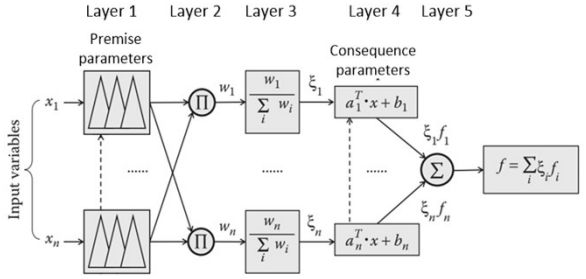

Figure 1. The basic the adaptive neuro-fuzzy inference system (ANFIS) structure

Layer 1 – Fuzzification of inputs (x_1, …, x_n)) using triangular membership function (MF). **Layer 2 –** Evaluation of the rule strength (w_i). **Layer 3 –** Normalizing the strengths of all rules ($\bar{w}_i$). **Layer 4 –** Applying the rule (R_i) to obtain the output f_i. **Layer 5 –** Computing the global model response (f).

$$R_i : if \left(x_1 \; is \; A_1^{(i)}\right) \ldots and \ldots \left(x_n \; is \; A_n^{(i)}\right) \; then \; f_i = a_i^T \cdot x + b_i$$

MAIN ISSUES

WS quality prediction is complex by its nature:

1. While QoS attributes are expressed in a numerical form and can be used to determine QoS using a data-driven prediction model, QoE attributes are usually expressed in **a non-numerical/linguistic form**.

For example: "Great item. Pictures pop thru and add detail as "painted" ☺. Pictures dry and it can be repainted."[1]

2. Different users have **diverse requirements** for various QoSs.

For example: in mobile apps to have a bigger set of features.

3. QoE remains **subjective**, and its evaluation is **expensive** and **tedious** because it requires a high human participation[2]. QoE data is missing in many problem domains.

[1] The amazon customer review feedback dataset sample. https://s3.amazonaws.com/amazon-reviews-pds/tsv/sample_us.tsv

[2] Letaifa, A. Ben. (2019). WBQoEMS: Web browsing QoE monitoring system based on prediction algorithms. International Journal of Communication Systems, 32(13), e4007. https://doi.org/10.1002/DAC.4007

METHODS

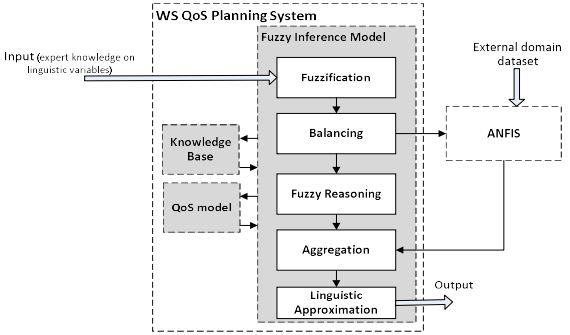

Figure 2. The hybrid fuzzy-based reasoning approach for predicting WS quality with ANFIS [3, 4, 5]

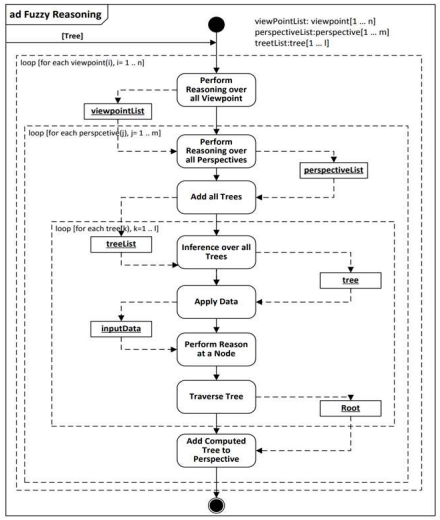

Figure 3. The fuzzy reasoning algorithm (according to [3, 4, 5])

CONCLUSIONS

- According to related works: the majority WS quality prediction systems are based on data-driven model and suitable to predict WS QoS, when input data is only numerical.
- A hybrid fuzzy reasoning approach for predicting WS quality with ANFIS has been proposed, implemented into a prototype and evaluated.
- The results of experiments show that the proposed approach is suitable to predict WS quality, when input data is not only numerical values, but also linguistic terms. Experiment 1 gives more accurate results than Experiment 2.
- In future work, we plan to refine the proposed approach, evaluate its efficiency, conduct new and more complex experiments.

RESULTS

- The user's need for a particular WS : "*As a Manager I want to submit an order quickly so that to do my job faster and have more free time*."
- The proposed approach is implemented and an experiment is conducted according to the approach (i.e., with ANFIS) (**Experiment 1**) and an experiment is conducted without ANFIS (**Experiment 2**).
- A group of six experts were involved to collect user's experience needs in linguistic form and translate them into data in numerical form.
- A real set of WS from WSDream [1, 2] dataset, which describes real-world response time and throughput values, obtained from 339 users on 5 825 WS, is used.

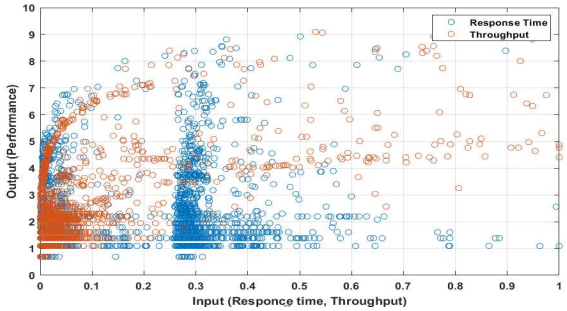

Figure 4. Distribution of initial data from WSDream dataset with respect to output data

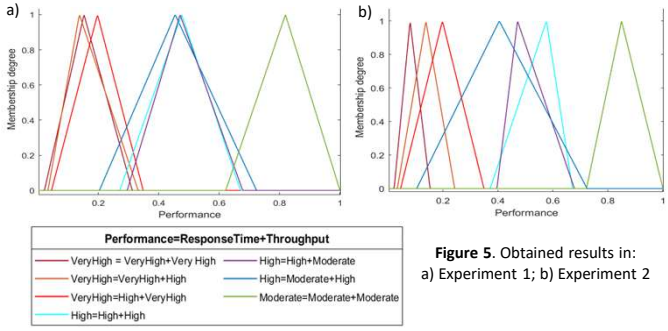

Figure 5. Obtained results in: a) Experiment 1; b) Experiment 2

- **Final result:** According to the initial user's need to submit an order quickly, we should have to provide a WS with Response time "high" or "moderate" and Throughput "high" or "moderate", but not "moderate" both.

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