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SERIES P: TELEPHONE TRANSMISSION QUALITY,
TELEPHONE INSTALLATIONS, LOCAL LINE
NETWORKS

Statistical analysis, evaluation and reporting guidelines of
quality measurements

**Guidance for the development of machine-
learning-based solutions for QoS/QoE
prediction and network performance
management in telecommunication scenarios**

Recommendation ITU-T P.1402

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Recommendation ITU-T P.1402

Guidance for the development of machine-learning-based solutions for QoS/QoE prediction and network performance management in telecommunication scenarios

Summary

Recommendation ITU-T P.1402 introduces machine-learning techniques and their application for quality of service (QoS) and quality of experience (QoE) prediction and network performance management in telecommunication scenarios. Especially, the design of training and evaluation data is described and means to avoid overtraining for machine-learning models.

The relation to classical model or algorithm development is also discussed, and the differences are described. This Recommendation gives best practice guidance for the successful development and evaluation of models based on machine learning but does not describe concrete models or algorithms for a specific purpose.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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AI, artificial intelligence, cleansing, machine learning, ML, network performance prediction, overfitting/underfitting, voice/video QoE/QoS prediction.

* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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Recommendation ITU-T P.1402

Guidance for the development of machine-learning-based solutions for QoS/QoE prediction and network performance management in telecommunication scenarios

1 Scope

Machine-learning (ML) and artificial-intelligence (AI) algorithms can be applied for networks performance evaluation, monitoring and troubleshooting techniques, and voice/video quality of service (QoS) and quality of experience (QoE) prediction models such as the ones developed by ITU-T.

A powerful technique, ML is inherently very complex and therefore prone to misuse and misinterpretation, which can consequently drastically impact the strengths and benefits of ML techniques. Therefore, it is required to carefully follow well defined guidelines when applying ML.

Thus, this Recommendation introduces general guidelines for applying ML within the context of ITU-T which are suitable to these techniques. In addition to the guidance provided by this Recommendation, it is suggested that the guidance given in [b-ITU-T P.Suppl. 28] also be taken into account.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- | | |
|-----------------|---|
| [ITU-T E.475] | Recommendation ITU-T E.475 (2020), <i>Guidelines for intelligent network analytics and diagnostics</i> . |
| [ITU-T P.10] | Recommendation ITU-T P.10/G.100 (2017), <i>Vocabulary for performance, quality of service and quality of experience</i> . |
| [ITU-T P.565] | Recommendation ITU-T P.565 (2021), <i>Framework for creation and performance testing of machine learning based models for the assessment of transmission network impact on speech quality for mobile packet-switched voice services</i> . |
| [ITU-T P.565.1] | Recommendation ITU-T P.565.1 (2021), <i>Machine learning model for the assessment of transmission network impact on speech quality for mobile packet-switched voice services</i> . |

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the terms defined in [ITU-T P.10].

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AI	Artificial Intelligence
CV	Cross Validation
MAE	Mean Absolute Error
ML	Machine Learning
MSE	Mean Squared Error
PCA	Principal Component Analysis
QoE	Quality of Experience
QoS	Quality of Service
RMSE	Root Mean Squared Error

5 Conventions

None.

6 Application of machine learning and artificial intelligence in QoS/QoE related measurements and network performance's management

In many cases, ML and AI terms are used interchangeably, although they are not the same. Their definition is quite complex and to some extent still disputed, at least in the telecom industry. For the purpose of this Recommendation, a high-level clarification [b-Mills] on the two terms is discussed and proposed.

AI is the science and engineering of making intelligent machines, especially intelligent computer programs. These machines are programmed to different levels of complexity, from being able to perform a single, repetitive motion (also known as automation) to adapting to different situations. AI is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable. For example, it might be possible to use AI terminology for some solutions which solve network diagnosis problems.

Machine learning is technically a branch of AI, but it is more specific than the overall concept. Machine learning is defined by sets of mathematical and statistical algorithms which use computational methods to learn information directly from data without relying on a predetermined equation as a model. For example, it is likely to use ML terminology for solutions which can use more controllable inputs and outputs (e.g., parametric QoE modelling).

For the purpose of this Recommendation, the term "ML" is used hereafter and should be read as "ML and/or AI".

6.1 General best practices for applied ML

While this clause is not exhaustive, some main best practices and concepts of applying machine learning [b-Domingo], [b-Precup], [b-Brodley], [b-Weston], [b-ICML], [b-Bengio] are mentioned below.

- Arguably the most important factor in successful machine-learning projects is the *features* used to describe the data (which are domain-specific) and having adequate data to train models in the first place. The term *features* means either those provided as input to the ML algorithm or the ones that the algorithm builds itself, such as in the case of neural network algorithms.
- When algorithms do not perform well, it is mostly due a to a problem with the learning/training data, such as insufficient amounts and/or skewed data; noisy data; or insufficient features describing the data for making decisions