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Recommendation

ITU-T F.743.22 (12/2022)

SERIES F: Non-telephone telecommunication services

Multimedia services

Requirements and architecture of an algorithm-training system for intelligent video surveillance

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Recommendation ITU-T F.743.22

Requirements and architecture of an algorithm-training system for intelligent video surveillance

Summary

Recommendation ITU-T F.743.22 specifies requirements and architecture for algorithm-training systems (ATSs) for intelligent video surveillance (IVS) and provides the algorithm-training workflow within it. The intelligent analysis algorithm in IVS needs to train a large amount of actual scene data to improve the accuracy and the recall of identification. The ATS can collect video and image data from the IVS, complete sample data selection and annotate data, as well as training and deploying algorithms in the IVS, so that the IVS has the reasoning capability of new scenarios and the ATS can continuously iteratively improve on algorithm identification performance. Recommendation ITU-T F.743.22 aims to solve the problems of difficult application of algorithm customization in various industries, long algorithm development and iteration cycle, and effective protection of user privacy and improvement of data security.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Algorithm-training system, architecture, intelligent video surveillance, requirement, workflow.

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Requirements and architecture of an algorithm-training system for intelligent video surveillance

1 Scope

This Recommendation specifies requirements and architecture for algorithm-training systems (ATSs) for intelligent video surveillance (IVS) and provides the algorithm-training workflow within it.

The scope of this Recommendation includes:

– an overview of ATS for IVS;

– requirements for ATS for IVS; and

– architecture and reference points of ATS for IVS.

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 H.222.0] Recommendation ITU-T H.222.0V8 (2021), *Information technology – Generic coding of moving pictures and associated audio information: Systems.*

[ITU-T H.264] Recommendation ITU-T H.264V14 (2021), *Advanced video coding for generic audiovisual services*.

[ITU-T H.265] Recommendation ITU-T H.265V8 (2021), *High efficiency video coding*.

[ITU-T H.626] Recommendation ITU-T H.626V2 (2019), *Architecture requirements for video surveillance system.*

[ITU-T H.626.5] Recommendation ITU-T H.626.5V2 (2022), *Architecture for intelligent video surveillance systems*.

[ITU-T T.81] Recommendation ITU-T T.81 (1992), *Information technology – Digital compression and coding of continuous-tone still images – Requirements and guidelines*.

[IETF RFC 3550] IETF RFC 3550 (2003), *RTP: A transport protocol for real-time applications.*

[IETF RFC 4571] IETF RFC 4571 (2006), *Framing real-time transport protocol (RTP) and RTP control protocol (RTCP) packets over connection-oriented transport.*

[IETF RFC 9110] IETF RFC 9110 (2022), *HTTP semantics.*

[IETF RFC 9112] IETF RFC 9112 (2022), *HTTP/1.1*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 accuracy [b-ISO/IEC 2382]: Quantitative measure of the magnitude of error, preferably expressed as a function of the relative error, a high value of this measure corresponding to a small error.

3.1.2 algorithm [b-ISO/IEC 11557]: A set of rules for transforming the logical representation of data.

3.1.3 data annotation [b-ISO/IEC 22989]: Process of attaching a set of descriptive information to data without any change to that data.

NOTE – The descriptive information can take the form of metadata, labels and anchors.

3.1.4 data storage and service (DSS) [ITU-T H.626.5]: The storage and sharing centre for video and image information within the intelligent video surveillance system. The DSS accepts registration, keepalive reports from the intelligent premises unit (IPU), intelligent video management (IVM) or intelligent application service (IAS) and obtains video and image information from them. It can also provide information network sharing services such as information querying, subscription, guard and alarm, etc.

3.1.5 intelligent application service (IAS) [ITU-T H.626.5]: The intelligent application service (IAS) is located at the application service core of the intelligent video surveillance system. Its main functions include providing application services about the video and image information, such as information query and retrieval, subscription and notification, manual annotation, etc.; providing external operations such as the creation and start-up of intelligent analysis tasks based on intelligent video management (IVM); obtaining the list of devices from the central control server (CCS) or data storage and service (DSS) and sharing them with the IVM so that it can schedule intelligent video units (IVUs) for video stream analysis, etc.

3.1.6 intelligent premises unit (IPU) [ITU-T H.626.5]: The premises subsystem within the intelligent video surveillance system. The premises intelligent video (PIV) module is added to the premises unit (PU) for intelligent video analysis.

3.1.7 intelligent video unit (IVU) [ITU-T H.626.5]: The intelligent video unit (IVU) identifies specific objects automatically, and outputs recognition results to an intelligent video management (IVM) system. The recognition information includes triggered events and acquired data. One or more intelligent analysis algorithms can be loaded or unloaded on an intelligent video unit (IVU) according to different requirements.

3.1.8 media distribution unit (MDU) [ITU-T H.626.5]: The media distribution unit (MDU) is used to transport media from the premises unit (PU) to the customer unit (CU). Its main functions include media receiving, media processing, media routing, media transmission, media forwarding and media replication.

3.1.9 media server [ITU-T H.626]: A device located at the centre part of a video surveillance system. It is used to forward real-time media stream as well as store, retrieve and replay historical media stream. The media server receives the media stream from premises unit or other media server and forwards the media stream to other customer unit or media server. It consists of media distribution unit and media storage unit.

3.1.10 model [b-ISO/IEC TR 29119-11]: Output of an ML algorithm trained with a training dataset that generates predictions using patterns in the input data.

3.1.11 recall [b-ISO/IEC TR 29119-11]: Performance metric used to evaluate a classifier, which measures the proportion of actual positives that were predicted correctly.

3.1.12 sample [b-ISO/IEC 22989]: Atomic data element processed in quantities by a machine learning algorithm or an AI system.

3.1.13 training dataset [b-ISO/IEC TR 24029-1]: Set of samples used to fit a machine learning model.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 algorithm management unit (AMU): A subsystem unit of the algorithm-training system that provides model warehouse management, model adaptation, model packaging and algorithm deployment.

3.2.2 algorithm training: A technology that learns the experience or the environment represented by input data and upgrades the algorithm.

3.2.3 algorithm-training management (ATM): A subsystem unit of the algorithm-training system (ATS), which provides the management of the sample management unit (SMU), the training management unit (TMU) and the algorithm management unit (AMU).

3.2.4 algorithm-training system (ATS): A system composed of algorithm-training management (ATM), sample management unit (SMU), training management unit (TMU) and algorithm management unit (AMU), which provides algorithm-training services for intelligent video surveillance (IVS).

3.2.5 sample management unit (SMU): A subsystem unit of the algorithm-training system that provides training dataset management, data annotation and annotation information storage.

3.2.6 training management unit (TMU): A subsystem unit of the algorithm-training system that provides algorithm-training task management, algorithm training, and model verification and evaluation.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AMU Algorithm Management Unit

ATM Algorithm-Training Management

ATS Algorithm-Training System

CCS Central Control Server

CIV Client Intelligent Video

CMU Central Management Unit

DSS Data Storage and Service

HTTP Hypertext Transfer Protocol

IAS Intelligent Application Service

ICU Intelligent Customer Unit

IPU Intelligent Premises Unit

IVM Intelligent Video Management

IVS Intelligent Video Surveillance

IVU Intelligent Video Unit

JPEG Joint Photographic Experts Group

JSON JavaScript Object Notation

MDU Media Distribution Unit

MP4 Moving Picture Experts Group 4

MS Media Server

MSU Media Storage Unit

PIV Premises Intelligent Video

RTCP Real-time Transport Control Protocol

RTP Real-time Transport Protocol

SCU Service Control Unit

SMU Sample Management Unit

TMU Training Management Unit

5 Conventions

In this Recommendation:

– The phrase "**is required to**" indicates a requirement that must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

– The phrase "**is recommended**" indicates a requirement that is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

– The phrase "**can optionally**" indicates an optional requirement that is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator or service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance to this Recommendation.

6 Overview

6.1 Introduction of the algorithm-training system for intelligent video surveillance

The intelligent analysis algorithm in an IVS needs to train a large amount of actual scene data to improve the accuracy and recall of identification. At present, there are many mature and general algorithms with high capabilities and wide applications.

Some algorithms, which may not be so common and mature, are specifically designed for a certain scenario, and may not be trained on a large amount of data at the time of deployment, or the training dataset may be different from the actual scenario. Users can use the same type of algorithm to identify objects, behaviours or attributes in the acquisition environment.

For example, one algorithm can identify smoke and fire. When smoke identification algorithms are also applied to identify fires in the same scene, they always need to be trained to improve accuracy. An algorithm is only as good as its training data. To make the algorithm accurate, continuous algorithm training is essential during the operation of the video surveillance system.

In some cases, uploading training data to external platforms for algorithm training is not allowed due to privacy and data security. For example, when an IVS system is deployed in a restricted area, algorithms are used to analyse whether the equipment is damaged or whether there is oil leaking on the ground. The videos and images taken from the restricted area are kept confidential, and they are not allowed to be uploaded to external platforms for algorithm training.

An ATS can solve this problem. The video and image collected by the IVS can be annotated, trained in the ATS, and deployed into the IVS locally. The purpose of algorithm training is to learn the law hidden behind the data. For data outside the training set having a similar or adapted law, the trained algorithm can give an appropriate output and it is considered that the algorithm has good generalization performance.

6.2 Algorithm-training workflow in the algorithm-training system

Algorithm-training workflow in the ATS can be divided into sample data collection, sample data annotation, algorithm training, model verification and evaluation, and algorithm deployment.

6.2.1 Sample data collection

The steps in sample data collection follow:

1) to create an algorithm-training task in the ATS according to the application scenarios, such as object classification and object detection;
2) to consult and analyse real-time or historical video and image data in the IVS;
3) to upload the optimized video and image data to the ATS after verification, cleaning and enhancement;
4) to create corresponding training datasets and classification categories according to the data types such as video or image;
5) to import the uploaded data into the corresponding training datasets.

6.2.2 Sample data annotation

The steps in sample data annotation follow:

1) to select the training dataset to be annotated and determine the method, such as annotation that is manual or automatic;
2) to annotate the data in the training dataset.

NOTE 1 – Manual annotation is performed by hand on new sample data by creating a single person annotation task or multi-person collaborative annotation task or re-annotate by modifying or deleting labels on the annotated sample data.

NOTE 2 – Automatic annotation is the process of refining existing annotation labels of video and image recordings using existing models in the system for intelligent annotation.

6.2.3 Algorithm training

The steps in algorithm training follow:

1) to create a model warehouse;
2) to create a training task, select a training dataset and configure the available computing resources;
3) to execute all elements in the training task list (e.g., start, stop, recreate, retrieve);
4) to store the trained model in the model warehouse.

6.2.4 Model validation and evaluation

The steps in model verification and evaluation follow:

1) to upload the verification sample data to the ATS;
2) to use the trained model inference to analyse the multiple verification sample data and comprehensively evaluate the model;
3) to visualize the results of the analysis;
4) to manually verify the results of the analysis.

6.2.5 Algorithm deployment

The steps in algorithm deployment follow:

1) to select the optimal model according to its evaluation results;
2) to check the hardware and software information about the device to be deployed, and generate a model that matches the device;

3) to pack the model and runtime-related components into the algorithm and upload it to the device to be deployed, and then start the algorithm upgrade – after the upgrade is complete, the device enables the new algorithm for inference.

NOTE – "The device" is the one in the IVS.

7 Requirements of the algorithm-training system for intelligent video surveillance

In this Recommendation, requirements specific to the ATS for IVS are identified.

7.1 General requirements

The ATS:

– is required to support algorithm scheme management, including but not limited to object classification and object detection;

– can optionally support data isolation, data encryption and data protection.

7.2 Requirements of sample data collection

7.2.1 General requirements

– The sample data is recommended to satisfy homology, diversity and balance.

7.2.2 Requirements of training dataset

The training dataset is required to:

– support addition, deletion, modification and querying of datasets.

– support video and image type datasets;

– support the release of the dataset version;

– meet the minimum number of training samples.

7.2.3 Requirements of sample data collection method

The system is required to support:

– video and image collection from the IVS (the collection method is specified in [ITU-T H.626]);

– single and batch manual uploads of local video and image files.

7.2.4 Requirements of sample data quality

The sample data is required to satisfy:

– absence of imaging quality issues, such as overexposure, excess darkness and abnormal deformation;

– the requirements of the algorithm scheme, including but not limited to image resolution and the proportion of the objects in the image;

– that the object is clearly visible and of appropriate size.

7.2.5 Requirements of sample data format

The sample data format is required to support:

– [ITU-T H.264] and [ITU-T H.265] encoded video data in Moving Picture Experts Group 4 (MP4) [ITU-T H.222.0] format;

– JPG format, Joint Photographic Experts Group (JPEG) (see [ITU-T T.81]) and portable network graphics format image data.

7.2.6 Requirements of sample data processing

– The system is required to support the validation, cleaning and enhancement of sample data.

7.3 Requirements of sample data annotation

7.3.1 General requirements

The system:

– is required to support manual annotation and automatic annotation;

– is recommended to support single-person manual annotation and multi-person collaborative manual annotation;

– is required to support multiple annotation types, including but not limited to image classification and object detection.

7.3.2 Requirements of annotation attribute management

The system is required:

– to support annotation attribute management;

– to provide preset annotation attributes for use;

– to support creation, retrieval, updating and deletion of custom annotation attributes.

7.3.3 Requirements of annotation function

The system is required to support:

– object annotation of videos or images;

– multi-object annotation;

– object annotation for location, size and shape;

– multiple attribute annotations for objects;

– scaling annotations.

7.3.4 Requirements of annotation description

The annotation description is required to support:

– the JavaScript object notation (JSON) [b-Wright] description format;

– metadata definition for annotation types.

7.4 Requirements of algorithm training

7.4.1 Requirements of computing resource management

The system is required to support:

– matching specifications of computing resource pools based on the training objects;

– heterogeneous computing resource pool management;

– load-balancing management of computing resource pools;

– permission control for computing resource pools;

– status monitoring of computing resource pools, including but not limited to fault alarms, and resource utilization statistics.

7.4.2 Requirements of algorithm-training task management

The system is required to support:

– the classification of algorithm-training tasks;

– algorithm-training task management, including creation, start, stop, and deletion;
– manual and automatic pause and resume of algorithm-training tasks;
– algorithm task status management, including but not limited to execution progress query.

7.4.3 Requirements of model validation and evaluation

– The system is required to support model verification, including but not limited to accuracy, recall and mean average precision.

7.5 Requirements of algorithm deployment

7.5.1 General requirements

The system:
– is required to support model packaging;
– is required to support algorithm release;
– is recommended to support algorithm orchestration.

7.5.2 Requirements of model management

The system is required to support:
– trained model viewing and support appropriate trained model archiving;
– create, retrieve, update, and delete of the archived models.

7.5.3 Requirements of deployment task management

– The system is required to support creation, retrieval, updating and deletion of deployment tasks.

7.5.4 Requirements of deployment status management

The system is required to support the retrieval of:
– the deployment status of devices in the IVS;
– the deployment time and version information of devices in the IVS.

7.5.5 Requirements of model warehouse

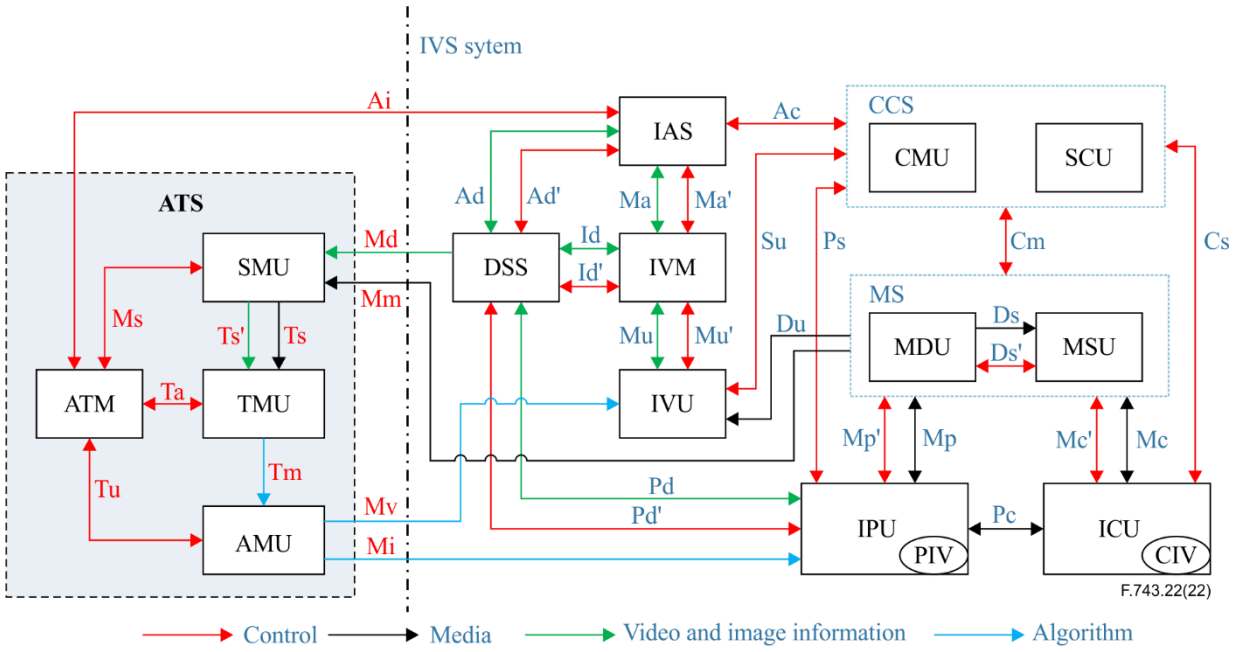
The model warehouse:
– is required to support the management, and storage of models;
– is recommended to support model conversion and validation.

NOTE – Model conversion refers to the system that converts the model to adapt to the different chips.

8 Architecture of the algorithm-training system for intelligent video surveillance

8.1 Functional architecture

Figure 1 shows the functional architecture of the ATS for IVS.



CIV: client intelligent video

Figure 1 – Functional architecture of the algorithm-training system for intelligent video surveillance

The functional architecture of the ATS for IVS is based on the functional architecture of the IVS system, which is specified in [ITU-T H.626.5].

Central management unit (CMU), service control unit (SCU), MDU and media storage unit (MSU) are defined in [ITU-T H.626].

The terms IPU, intelligent customer unit (ICU), IVM, IVU, DSS and IAS are defined in [ITU-T H.626.5].

The ATS is composed of ATM, SMU, TMU and AMU.

This Recommendation describes units such as the ATM, SMU, TMU and AMU in clauses 8.1.1 to 8.1.4 and reference points in clause 8.2.

8.1.1 Algorithm-training management

ATM is a subsystem unit within the ATS.

The functions of the ATM are to:

– obtain a media, video and image information resource list;
– provide an algorithm list;
– manage algorithm-training tasks;
– manage annotation tasks;
– manage algorithm deployment tasks.

8.1.2 Sample management unit

An SMU is a subsystem unit within the ATS.

The functions of the SMU are to:

– create training datasets of media, video and image information;
– create, retrieve, update and delete annotation tasks;
– annotate the training dataset and store the annotation information.

8.1.3 Training management unit

A TMU is a subsystem unit within the ATS.

The functions of the TMU are to:

– create, retrieve, update, and delete training tasks;
– verify and archive trained models.

8.1.4 Algorithm management unit

An AMU is a subsystem unit within the ATS.

The functions of the AMU are to:

– create, retrieve, update, and delete the model warehouse;
– manage and store the model;
– package models into algorithms;
– deploy the algorithm.

8.2 Reference points

Reference points Cm and Ds/Ds' are specified in [ITU-T H.626].

Reference points PS, Mp/Mp', Pc, Cs, Mc/Mc', Su, Du, Mu/Mu', Ma/Ma', Ad/Ad', Id/Id', Pd/Pd' and Ac are specified in [ITU-T H.626.5].

This Recommendation specifies reference points Ai, Ms, Ta, Tu, Md, Mm, Ts/Ts', Tm, Mv, and Mi.

8.2.1 Reference point Ai: IAS – ATM

Reference point Ai is between the IAS and the ATM.

It is used to:

– retrieve the device list for algorithm upgrade from the ATM to the IAS;
– send algorithm upgrade notifications from the ATM to the IAS.

8.2.2 Reference point Ms: SMU – ATM

Reference point Ms is between the SMU and the ATM.

It is used to:

– register or de-register and keepalive from the SMU to the ATM;
– send a training dataset creation command from the ATM to the SMU;
– send a sample annotation task creation command from the ATM to the SMU;
– send a sample annotation task status from the SMU to the ATM;
– send a resources usage status from the SMU to the ATM.

It uses the hypertext transfer protocol (HTTP) [IETF RFC 9110] and [IETF RFC 9112] + JSON protocol.

8.2.3 Reference point Ta: TMU – ATM

Reference point Ta is between the TMU and the ATM.

It is used to:

– register or de-register and keepalive from the TMU to the ATM;
– send an algorithm-training task creation command from the ATM to the TMU;
– send an algorithm-training task status from the TMU to the ATM;

– send an algorithm-training capability and resource usage status from the TMU to the ATM.

It uses the HTTP + JSON protocol.

8.2.4 Reference point Tu: AMU – ATM

Reference point Tu is between the AMU and the ATM.

It is used to:

– register or de-register and keepalive from the AMU to the ATM;
– send a model warehouse to create and retrieve a command from the ATM to the AMU;
– send an algorithm deployment command from the ATM to the AMU;
– send an algorithm deployment status from the AMU to the ATM.

It uses the HTTP + JSON protocol.

8.2.5 Reference point Md: DSS – SMU

Reference point Md is between the DSS and the SMU.

It is used to:

– transmit video and image information from the DSS to the SMU through the HTTP + JSON protocol.

8.2.6 Reference point Mm: MS – SMU

Reference point Mm is between the media server (MS) and the SMU.

It is used to:

– transmit media from the MS to the SMU through the real-time transport protocol (RTP) [IETF RFC 3550] or real-time transport control protocol (RTCP) [IETF RFC 4571].

8.2.7 Reference point Ts/Ts': SMU – TMU

Reference points Ts/Ts' are between the SMU and the TMU.

Ts is used to:

– transmit media from the SMU to the TMU through the RTP or RTCP.

Ts' is used to:

– transmit video and image information from the SMU to the TMU through HTTP + JSON protocol.

8.2.8 Reference point Tm: TMU – AMU

Reference point Tm is between the TMU and the AMU.

It is used to:

– transmit a model from the TMU to the AMU through the HTTP.

8.2.9 Reference point Mv: AMU – IVU

Reference point Mv is between the AMU and the IVU.

It is used to:

– transmit an algorithm from the AMU to the IVU through HTTP.

8.2.10 Reference point Mi: AMU – IPU

Reference point Mi is between the AMU and the IPU.

It is used to:

– transmit an algorithm from the AMU to the IPU through HTTP.

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