OPC UA for Machine Vision
VDMA Webinar Series

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Machine Vision systems - Immense variety in systems and applications

Broad system range
• Vastly different system types
• Wide variations in performance and flexibility
• Diverse communication interfaces

Enormous application variety
• Different configurations
• Different results
• Different time behaviour
• Vast potential for misunderstandings…
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Development of OPC Machine Vision - Timetable

TWG Kickoff
CWG Kickoff
1st draft (V 1.0, 56 pp.)
Release Candidate (V1.9, 146 pp.)
Official submission (V1.55, 160pp.)
FINAL (V1.83, 182 pp.)

2017-03
2017-06
2018-01
2018-06
2018-12
2019-05
2019-04
2019-07
2019-11

TWG: Total Working Group
CWG: Core Working Group
TIG: Test Implementation Group

Timeline preparation phase
- Initialisation meeting (2017-03)
- Core Working Group (2017-06)
- First public show with actual MV systems (2019-11)

Timeline core working phase
- CWG Kickoff (2017-06)
- CWG meeting (2017-07)
- CWG meeting (2017-10)
- CWG meeting (2018-01)
- CWG meeting (2018-06)
- CWG meeting (2018-12)

Timeline finalization phase
- TIG Kickoff (2018-12)
- TIG meeting (2019-04)
- TIG meeting (2019-07)
- TIG meeting (2019-11)

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Members of the Working Group

Total Working Group of approx. 60 stakeholder companies

Core Working Group of 17 engineers

data provider representatives

data consumer representatives
IVSM – annual International Vision Standards Meeting

VDMA gives mandate

accepts

specifies

OPC Machine Vision

accepts

Robots + Automation
OPC Machine Vision
Part 1
Details of identifiers and state machines
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Conceptual model vs. OPC UA model

Before creating an OPC UA model … … we felt that we needed a common understanding of what a vision system is … … which should not need to be re-implemented … … but complemented by the OPC UA model … … regardless of size … and additional vendor-specific functionality.
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OPC UA server vs. Actual system

The behaviour of the system may be influenced by

- An operator
- Various non-OPC UA interfaces
- Multiple OPC UA clients calling methods in a possibly uncoordinated way

The OPC UA server provides a **view** on the system, it is not the system.

All clients need to see the behaviour of the system through this view.
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Types of data

• Vision system input and output (e.g., from and to MES)
  • Recipes
    … describe a job for the vision system by properties, procedures and parameters
  • Configurations
    … ensure that different vision systems generate equal results for the same recipe

• Vision system output
  • Results
    … are produced when a vision system acquired and processed data by a recipe
  • Events and Conditions
    … inform clients about occurrences and circumstances in the vision system

• Except for wording, this is probably a relative generic concept
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Focus on functionality

Data content very hard to generalize → focus on control of vision systems by clients

• Methods for managing data (as black boxes)
• Methods and events for controlling and observing behaviour
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Recipes and configurations

• May be simple in form and content or very complex
  → Allow for address space representation and/or black-box handling

• May contain valuable intellectual property
  → Allow for black-box handling, possibly with encryption

• May be created, edited, and managed locally on the system itself or centrally, e.g. in an MES
  → Allow for bi-directional exchange, unique and extensible identification, and version control by appropriate meta data
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Results

• May be small and simple or complex and very large
  → Allow for address space representation and/or black-box handling

• May be needed immediately for control purposes or only later for quality logging and analytics
  → Allow for transporting in events and for persistence and querying

• May need to be traceable to jobs, parts, recipes, and configurations
  → Provide appropriate meta data

• May have always the same structure or depend on the recipe and vary at worst with each job
  → Use flexible placeholders and/or black-box handling and provide meta data to link to recipes used
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Data management philosophy

- **Address Space representation**
  - Always optional to facilitate tailoring for less powerful systems
  - Typically only metadata in the Address Space, no content
- **Get methods**
  - Accept filter parameters for a subset of items (except for configurations)
  - Return a list of matching items
- **Add/Remove methods**
  - Map external Ids from the client-side and internal Ids from the system
- **Black-box Content transfer**
  - Works through Temporary File Transfer (see OPC UA Part, Annex D)
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Error handling (designed together with Robotics)

- **Client and user information and interaction**
  - Uses standard OPC UA alarms and condition mechanisms (see OPC UA Part 9)
  - Uses standard OPC UA severity model (see OPC UA Part 5)
  - Acknowledgement (event has been received by a client) is typically automatic
  - Confirmation (corrective action has been taken) is typically manual
  - Several (error) conditions can exist simultaneously
  - Error conditions do not necessarily result in suspension of normal operation

- **Suspension of normal operation**
  - Top-level *Error* to be entered if normal operation cannot continue without corrective action (common handling for all operating modes!)
  - Information by acknowledgeable condition mandatory
  - System decides based on situation which *State* is reached after error is resolved
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Mandatory standardized top level state machine

- **Hierarchical state machines**
  - Mandatory top level state machine for common startup and error behaviour.
  - Optional predefined state machine for a typical automatic mode as sub-state-machine of „Operational“.
  - Vendors can provide additional operating modes in the same way as parallel sub-state-machines.
  - Optional step model sub-state-machine in each state for dynamic handshaking with clients.
  - All transitions possible by methods or automatic (for modelling control through other interfaces than OPC UA)
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Mandatory standardized top level state machine
For common overall behavior of standard compliant systems

Extensibility for future standard or vendor-specific modes of operation
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Standardized automatic mode sub-state-machine (optional)

For built-in standard “automatic mode” behaviour

Vendors can add own sub-state machines for other modes of operation

Self terminating Jobs

Recipe Selection

Continuously running Jobs

Recipe Selection
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Optional step model sub-state-machine on each main state

For transparent synchronization processes with the client

Generic substitute for …ing States

Bypass

Step Model with Handshake

Number of steps can dynamically be changed (0 .. N)
Example for adding extended functionality to the Operational State Machine

- A Vision system has to inspect two sides of an object using a camera mounted on a robot arm
- The robot has to be triggered to move to the positions for inspection
- The vision system has to wait till the position is reached before it can acquire an image

To implement the needed handshake between vision system and robot an SSM is nested within the SingleExecution state S7
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The OPC Vision State Machine – Example Step Model SSM
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The OPC Vision State Machine – Example Step Model SSM

Ready
S6
StartSingleJob() / --

SingleExecution
S7

Entry
S7.S11

Wait
S7.S13
Sync() / --

Step
S7.S14
NextStep

Exit
S7.S12

-- / Ready

-- / EnterStepSequence

-- / LeaveStepSequence

-- / NextStep
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The OPC Vision State Machine – Example Step Model SSM
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The OPC Vision State Machine – Example Step Model SSM
Thank you for your attention!

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