Extended Matrix

Release 1.2

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CONTENTS

Extended Matrix is a formal language with which to keep track of virtual reconstruction processes. It is intended to be used by archaeologists and heritage specialists to document in a robust way their scientific activities. The EM allows to record the sources used and the processes of analysis and synthesis that have led from scientific evidence to virtual reconstruction. It organises 3D archaeological record so that the 3D modelling steps are smoother, transparent and scientifically complete. It has been developed by E. Demetrescu at CNR-ISPC (Rome, former CNR-ITABC). EM is at its 1.2 version (a 1.3 version is currently under development).

In a wider perspective and due to its abstract approach, the Extended Matrix can be used as a human readable metaphor to ingest and present liquid semantic data. In other words, the nodes that compone the paradata section can be used to track and annotate in a simple but effective way several data provenance path exceeding the traditional reconstruction process it was firstly applied to.

Check out the *Usage* section for further information, including how to *Installation* the project. For the description of the nodes, see *Nodes of the EM* For the properties, see *Properties of the EM*

Note: This project is under active development.

CHAPTER

ONE

CONTENTS

1.1 Usage

1.1.1 Installation

To use Extended Matrix, first install yED and Blender:

Here you can find the download page: https://www.extendedmatrix.org/download

1.1.2 Creating your first EM project

A god way to learn how to create your first EM project, look at this quickstart https://youtu.be/M3Rwu9qS4P0

1.2 A stratigraphic approach

1.2.1 Why a stratigraphic granularity in virtual reconstruction ?

The main focus of the stratigraphic reading is the chronological sequence (what is newer, what is older) and for that reason is finer compared with other segmentations that identifies only the function of the objects. In other words, a stratigraphic reading does not only take into account the functional units (a wall, a floor) but subdivide them in their chronological transformations (i.e. wall creation, first restoration of the wall, creation of a window that cut the wall and its restoration, the window has been transformed into a door, the door is walled back, etc..). Working both with big sites like the Imperial Fora or with a small emergency excavation it is possible to follow the same methodology maintaining data consistency.

1.2.2 A granularity matter and the archaeological stratigraphy

As in figure 1, current limitations in virtual reconstruction are mainly in the data granularity: (a) the model obtained from the survey, or "reality based model", (b) the "source granularity approach": the model is divided according to a single source typology (square brackets) but each segment is normally based on different sources blended together (curly brackets). In this approach, the process used to obtain the stratigraphic unit from its sources remains only "into the mind of the archaeologists". (c) The proposed approach: it is possible to provide the source details for each SU. (d) The Extended Matrix regarding the previous Figure c. Taking in mind this situation, the EM granularity is based on the archaeological stratigraphy: it permits to have a per-object description of the reconstruction processes.

1.2.3 Common equivocacies about stratigraphic reading

A very common equivocacy about stratigraphy is that it concerns just earth strata or remains. The importance that archaeologists grant to the stratigraphy is directly connected to the need to have a tool as much "wide" as possible in term of semantic representation: dealing with a brush stroke on a canvas (painting stratigraphy annotation from x-ray), trees on a landscape, deposits of earth, architectonical elements or graffiti carved in a painted wall, the tool used is the same: the SU. It has a wide scope: it means "result of an action" and it is intended to be applied to every cultural element on a chronological timeline. These actions can be natural (earthquake interface of destruction, a tree, an interface of a flooding from the near river) or anthropic (a foundation, a lintel, the decoration of a lintel etc..). An interesting thing is that the SU, despite the fact that it can refer to different objects, can have always a precise and actual 4D representation (time and geometry).

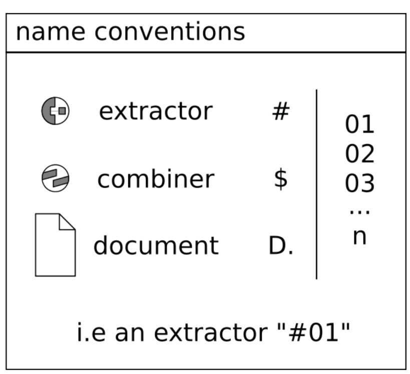
From a virtual reconstruction point of view, the most valuable aspect of the stratigraphic approach however is not only in its ductility of scenarios of use but in the possibility to annotate "negative" actions (and, in turn, the gaps in an existent "structure"): it is a convenient way to classify the elements that have been removed and have to be restored (reconstructed).

1.3 Nodes of the EM

EM uses two sets of standardized nodes: USV and validation nodes (see Fig. 1). The USV nodes represent virtual stratigraphic units (according to a specific typology) while the validation nodes express the reconstruction process behind the USV. These nodes are connected each other by arcs in the same way that it happens with the archaeological Matrix of Harris.

	Node	Description	Examples ref. sheet
	SU 9	**white rectangle = SU** (or US) stands for Stratigraphic Unit (or Context). A specialization is the -SU or negative stratigraphic unit that describes a gap on a SU.	B1
USV nodes	USV 100	**black parallelogram = USV/s** or structural Virtual Stratigraphic Unit is a reconstruction hypothesis made starting from an *in situ* fragmented SU. It acts as a restoration of a -SU so that its presence is physically "proved".	B1
USV nodes	USV 101	**black hexagon = USV/n** or non-structural Virtual Stratigraphic Unit (reconstruction hypothesis made starting from "sources" like comparisons, general rules etc..). It is not connected to a -SU and, as a result, it is not physically "proved".	B2
USV nodes	SF 1	**white octagon = Special Find.** It refers to a not *in situ* element (fragmented or intact) that needs to be repositioned. It is a real object so that you know several properties (color, material, etc ..) *except* the original position.	B5
USV nodes	USV 102	**black octagon = Virtual Special Find**. It represents an hypothetical reconstruction of a fragmented Special Find (*not in situ* element).	B5
USV nodes	USV 103	**black ellipse = USV series.** A series of USVn objects like a colonnade or a sequence of acroterion can be considered as a whole. This seriation node acts like a proxy for the entire group.	B3
validation nodes	#01	**extractor icon = extractor** node capable of extracting specific information from the sources and passing it to a property.	C1
validation nodes	$01	**combiner icon = combiner** node capable of combining information provided by two extraction nodes and passing the resulting value to a property.	C2
validation nodes	material	**grey rounded square = property.** A property node validates a USV it is connected to. Examples of properties are "material", "dimension", "placement", etc..	C1
validation nodes	D.01	**document icon = source.** A source node feeds a property of a USV it is connected to (throught an extractor node). A source can be an image, a text, a reference, a 3D model etc.. More documents need a combiner node.	C1

Validation nodes have a unique name (as well as the USVs) in order to be correctly referenced. They follow a name convention model (see Fig. 2): extractor nodes are composed by a "D" plus a sequence of numbers (i.e the first extractor of an EM will be #01). Combiner and document nodes uses respectively the "C" and "D." prefix.



Extended Matrix nodes include all the graphic elements on the two-dimensional canvas except for the connecting lines between them, which are called arcs or connectors.

Nodes are divided into three major families: stratigraphic units, sources, and interpretation and reasoning nodes.

1.3.1 Taxonomy of the EM

Validation nodes can have different values. These lists are not "closed": users of the EM can add values in case of necessity.

img/Taxonomy.png

Taxonomy of terms in validation nodes

1.3.2 General background on stratigraphic units

A stratigraphic unit in some academic scholarships is also known as locus or context. It indicates the result of an action that occurred at a specific moment in time. The result (the construction of a wall, the destruction of a roof, is the silt deposited on top of structures following a flood, the chemical change of surfaces due to a fire) in turn have a life span that ends with the moment it is defunctionalized (destroyed, abandoned, buried).

Stratigraphic units that are of different types: real stratigraphic unit relating to something still existing or stratigraphically documented, documentary stratigraphic tip that the family of virtual stratigraphic units (relating to objects that no longer exist and need to be reconstructed). Abstract limits that are of different types: real stratigraphic unit relating to something still existing or stratigraphically documented, documentary stratigraphic tip that the family of virtual stratigraphic units (relating to objects that no longer exist and need to be reconstructed)

1.3.3 Stratigraphic Unit - US

It is the graphic and conceptual sign we use to number and define objects found still in situ (and noted using the techniques of stratigraphic reading).

1.3.4 Documentary Stratigraphic Unit - USD

The Documentary Stratigraphic Unit (USD) represents an element whose existence is certain due to a source considered reliable (a text, a drawing).

It connects to these properties:

- existence
- geometry
- placement
- material
- color
- etc..

1.3.5 Combiners

Combinator nodes can combine information provided by two extraction nodes and pass the resulting value to a property.

1.3.6 Extractors

Extractor nodes can extract specific information from a source and pass it to a property.

1.3.7 Property nodes

A property node validates a USV it is connected to. Examples of properties are "material", "dimension", "placement", etc. See *Properties of the EM* for more examples.

1.3.8 Sources

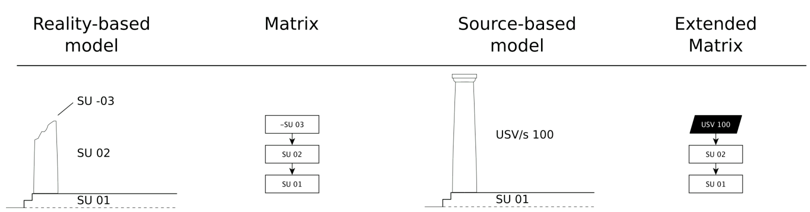
A source node feeds a property of a USV it is connected to (throught an extractor node). A source can be an image, a text, a reference, a 3D model etc.. More documents need a combiner node.

1.3.9 Relations among nodes

Connecting an SU with other existing ones (if any) is possible via a connector (a line with a terminal arrow connecting two nodes). In EM by convention the arrow always points to the oldest object (arrow pointing from top to bottom).

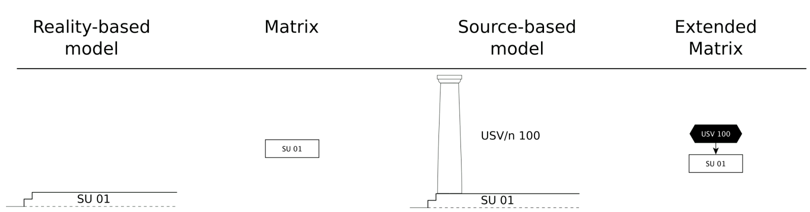
1.3.10 USV nodes, examples of use

Example of USV/s (structural virtual stratigraphic unit)



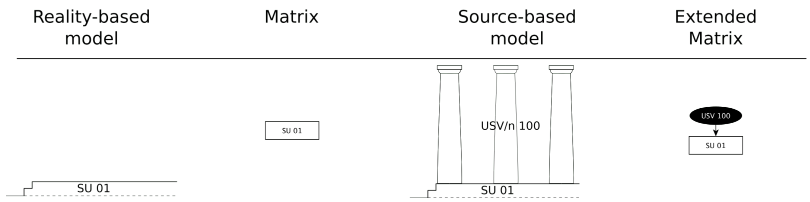
On top of a podium SU01 there is a SU02 (in situ), fragmented due to a -SU03 (destruction of the upper part of the column). A USV/s 100 hypothetical reconstruction is provisioned in order to restore the action of destruction -SU03.

Example of USV/n (non structural virtual stratigraphic unit)



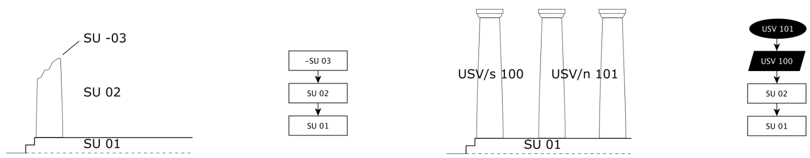
There are only the remains of a podium SU01. A USV/n 100 hypothetical reconstruction is provisioned (without physical destruction signs that prove the presence of a column).

Example of a series of USV/n (non structural virtual stratigraphic unit)



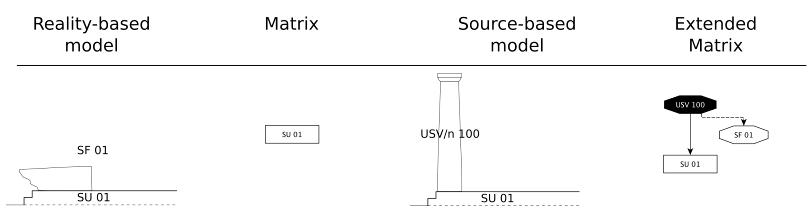
There are only the remains of a podium SU01. A USV/n 100 hypothetical reconstruction series of columns is provisioned (without physical destruction signs that prove the presence of a column). The series node allows to instance several USV/n at once.

Example of a USV/s and a series of USV/n



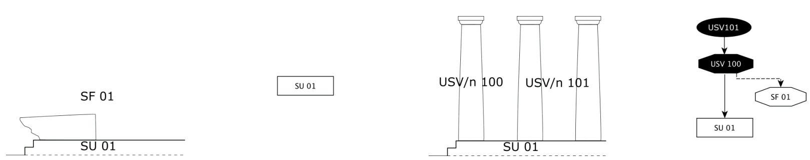
On top of a podium SU01 there is a column SU02 (in situ) fragmented due to a -SU03 (destruction of the upper part of the column). A USV/s 100 hypothetical reconstruction is provisioned in order to restore the destruction's action -SU03. A series USV/n 101 is provided in order to complete the peristasis of the temple.

Example of a USV/n based on Special Finds (non in situ) elements



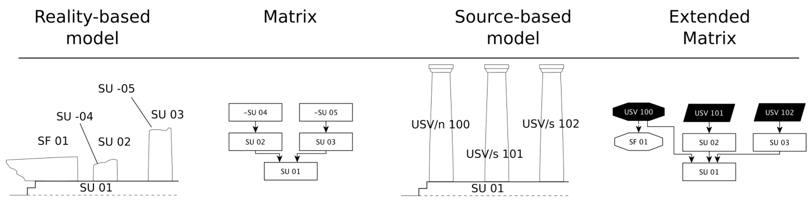
There are only the remains of a podium SU01 with a collapsed column SF01. A USV/n 100 hypothetical reconstruction is provisioned using the SF as a source. This kind of USV/n has a special status: see "USV and validation nodes" section on top of this page.

Example of a USV/n series based on Special Finds (non in situ) elements



There are only the remains of a podium SU01 with a collapsed column SF01 (special find 01). A USV/n 100 series hypothetical reconstruction of the columnade is provisioned using the SF as a source.

Cumulative example of different USV nodes used togheter

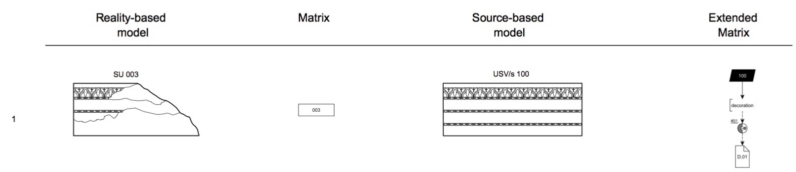


USV/s and USV/n are used togheter. Different -SU allow to propose different USV/s.

1.3.11 Validation nodes: examples of use

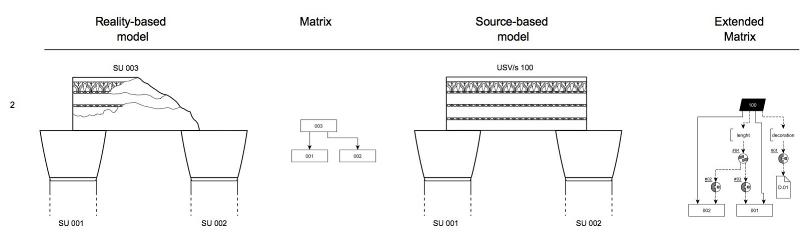
The USV is a hypothesis with three levels of certainty (structural-non structural-special find reintegration) that have some properties; these properties are based on: sources (nodes), interpretation of sources (extractor nodes) and reasoning (combiner nodes), following the DIKW schema Data-Information-Wisdom-Knowledge.

Example of a property based on a single source



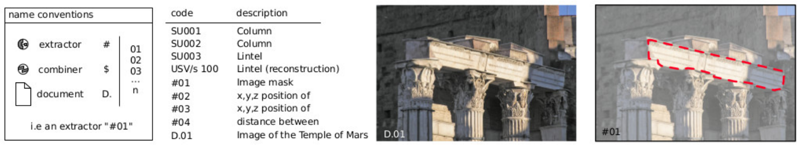
There is a fragmentary lintel SU003 and a reconstructed USV/s 100 is provisioned. A "decoration" property is declared and supported by a source D.01 (picture of the Temple of Mars at Rome). The interpretation of the source #01 extracts the part of the source useful to support the property above "decoration". The content of paradata nodes are visible at paragraph 3.3.

Example of a property based on two sources



There is a fragmentary lintel SU003 on top of two columns SU001 and SU002. A USV/s 100 provide a hypothesis of virtual reconstruction and two properties are declared: lenght and decoration (see previous paragraph). The lenght property is based on two sources, namely the position of the columns used to extract the overall lenght of the lintel. The content of paradata nodes are visible at paragraph 3.3.

Example of a validation node table



List of nodes used in the paragraphs 3.1 and 3.2:

1.4 Properties of the EM

1.4.1 What is a property ?

A property is an element that defines a quality of the object to be represented. Properties include

1.4.2 Existence

The existence property contains the wisdom of the existence of an element.

According to the kind of US-node it is connected to, it can be implicit or to be made explicit. An implicit existence is not mandatory nor suggested, an explicit existence should be declared.

An implicit existance is in the case of US/USM that are real elements you can see and touch. The same thing happens with the USV/s nodes that represents elements whose existence property is certain.

Examples of existence to be made explicit are USD, USV/n and VSF whose certainty of existence should be justified by mentioning the main proof we have.

1.4.3 Geometry

The geometry property defines the dimensions of the object (length, width, thickness, shape). Within the Extended Matrix, the geometry property can be defined, for example, by a floor plan or photogrammetric model of the area to be reconstructed.

1.4.4 Placement

Placement is the property that defines the exact location of geometry, either in local or global coordinates. The main sources from which to infer the positioning property of geometry are technical drawings, excavation plans, and photogrammetric models.

1.4.5 Material

Material property defines the material(s) of which the object is made. This characteristic can be inferred from various sources, such as excavation reports, ancient sources etc.

1.4.6 Color

The color property defines the original color(s) of the object. As with the *Material* property, it can be defined from excavation reports and ancient sources.

1.4.7 Shape

The shape of an object is a fundamental property for its reconstruction. In cases where the object has been preserved in its entirety, its shape can be inferred from photographs, surveys, drawings and descriptions. In the case where it has not been preserved, it can be inferred from ancient written and iconographic sources or from studies of the *Type* of the artifact.

1.4.8 Measures

The measurements of an object (height, width and depth) define its size and volume.

1.4.9 Type

The type property defines the classification of the object based on basic taxonomic criteria that are common to a group of artifacts, such as shape, material, decoration etc.

1.4.10 Decoration

Decoration is a feature of the surface of an artifact. It can be made during the production of the object (e.g. mold decoration, relief decoration etc.) or after it (e.g. graffiti) and can be a useful feature for dating it. The sources to draw on for the decoration property are varied, and depend on the nature of the object being examined: they include ancient sources as well as excavation reports, studies of the classification and typology of finds in a context, photogrammetric surveys etc.

1.4.11 Interpretation

Interpretation is the property that defines the function of an object or the reason for an action within the context that is to be reconstructed. Information on interpretation can be gathered from excavation reports.

1.5 Time management in the EM

1.5.1 Time Nodes

The representation of nodes in the EM also allows the temporal dimension to be handled, indicating whether SUs are still in existence. Single SUs still existing are represented with a rectangle, SUs in series with an ellipse, while the continuity of a SU's life through the phases is represented with a black rhombus.

1.5.2 Continuity nodes

The Extended Matrix makes it possible to represent the lifespan of a stratigraphic unit, enclosed between the moment of its execution and the moment of its destruction or de-functionalisation. In EM, the continuity of life is expressed through a continuity node (a black rhombus that marks the end of the life of the stratigraphic unit (the beginning is marked by the stratigraphic unit itself).