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# Propose Semantic Formalization for 3D Reconstruction of Architectural Objects

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## Abstract

Archi3D project is a successful practice well proved by engineering practices. In this paper, we propose to reconstruct semantics for the purpose of reconstruct 3D architecture in Archi3D fundamentally. The formalization approach starts from several hypotheses on semantics which include: there is a core mechanism of semantics which is not limited to conceptual expression level; and a complete expression of semantics necessaries the “implicit→explicit” transition of human side knowledge, etc. The necessity and feasibility concerning applying the proposed method and technology to the practice of Archi3D is discussed systemically by way of semantics revelations on some cases related to natural language and logic expressions, etc.

**Keywords:** Semantics, Language, Logics, Formal, Epistemology, Complete, Consistent, Cognition

## 1. Introduction

### 1.1 Project Archi3D overview

This is an update of previous publication of [19]. Archi3D [1, 2] projects have been proven successful and technologically mature in integrating knowledge engineering achievement specifically ontology methodologies and techniques, with sound mathematical algorithms to manipulate large scale 3D architecture data/objects in real professional engineering practices. Archi3D contributes greatly not only to the improvement of the computation efficiency and space saving but also to the automatic reconstruction/modeling, optimization and maintenance processes based on understanding/cognition on semantics at various abstraction (ABT) levels. By providing a sound knowledge base, it facilitates the collaboration and communication among various stakeholders, e.g., archaeologists, customers, etc, throughout the process of 3D reconstruction. Archi3D always catches up with the emerging cutting edge technology and international standards in the areas of SWRL, OWL, RDF, XML, etc, to pursue continuous eminence.

Although technically Archi3D has been progressing steadily and continuously towards the best, it seems to have explored/solved to the extreme from the methodological view concerning what has been identified as problems. In this draft,

new views are proposed to gain an expected investigation on what is left to be done and optimized. Also initial solutions are proposed with elementary discussions.

### 1.2 The obsession or benefit at the start point

A semantics formalization mechanism called EID-SCE [3] is initially proposed to understand, validate and express semantics in a fundamental formal manner. EID-SCE updates the semantics expression mechanism of minds. It takes effort to hold back the motivation to employ EID-SCE to formalize the informal natural language (NL) semantics of this draft which are supposed/expected to convey formally but have to be “deliberately” conveyed with NL. This is because of that general readers of this draft do not have the training/knowledge in EID-SCE. We also try to save description in NL since that introducing new words/concept(CPT) tends to be more likely to turn into part of the problem instead of part of the solution. In contrast to being limited to conceptual level, we believe that it is beneficial to introduce EID-SCE even partially/gradually for the purpose of semantics expression/understanding of this draft. Trivial modifications/adaptations are the forms of positive accumulation, if they go spirally towards structural consistency at the highest abstract level. (Although most of us are not guaranteed with a stable idea, what it will be like. You see how difficult or so called philosophical the discussion here could be if we want to clarify the NL semantics here with NL. But it will be helpful if we start to question something like “conceptual vs. (...)”. We’d better stop here! ). From the language initiation of Wittgenstein, we would like to extend the following as what our approach could be initially summarized as transition from NL related informal to formal semantics:  $|_{NL/(formal,informal)} \rightarrow |_{<formal, (...)>}$ ).

### 1.3 Initiative for reconstruction with semantics formalization

We propose that 3D reconstruction [6, 20, 21, 22] contains systemically 3D “semantics reconstruction”. Semantics reconstruction needs semantics formalization as much as it can be achieved. Although throughout semantic formalization is not necessary from an engineering view and not economically sound from a short view, semantics formalization complies/supports well with almost all scientific and engineering expectations such as high reusability|reliability|dependability, better automation, easier

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maintenance, and project development process control[5], etc, from a long time view.

We agree with what Bijan [4] claims as that using Web Ontology Language (OWL)[6] models in applications necessitates both a technical means of integrating OWL models with programs and considerable methodological sophistication in knowing how to integrate them. We would like to put it a little bit more forward as that not only integrations are needed but also bidirectional MTs (model transformations) are demanded for the full process support among various ABT levels of Archi3D models. They may include investigating a more flexible and robust way for combining description logics (DL) [7] and Semantic Web Rules Language (SWRL)[8] which is undecidable, etc.

#### 1.4 Related ideas from EID-SCE

EID-SCE considers the followings related to semantics in a unified manner:

(Semantics)<sub>EID-SCE</sub>

- Conceptual vs. (else...)
- CWA(Closed world assumption) vs. OWA(Open world assumption)
- Cautious with the conscious vs. unconscious
- \* We need to be cautious with assumed semantics of NL terms and stay clear minded with the semantics transitions during MT(model transformation) of design/implementation processes.
- Cautious with (Y(yes)/N(no))(T(true)/F(false))
- \* We need to distinguish the personally adopted subjective decisions which map to Y/N from objective decisions which map to generally accepted T/F.
- Cautious with backgrounds of various logics
- \* We need to distinguish usages of logic as description (DES) vs. implementation (IMP) of which various semantics criteria may apply. Both structural vs. dynamic organization of semantics are our ongoing investigation.

Solution initiatives proposed:

- Reach  $\langle \rangle$ (complete) through explicitly modeling/formalizing the previous implicit semantics, e.g. on human side: CM(cognitive model[9])<sub>implicit</sub>  $\rightarrow$  explicit
- Unify and reveal (Y/N)|(T/F) for expected semantics expressions. First individual transitions of “Y/N $\rightarrow$ T/F” need to be revealed, then all of them need to be connected as a seamless flow which guarantees the semantic flow of “subjective  $\rightarrow$  objective”
- Reach  $\langle \rangle$  , Consistency , No redundancy  $\rangle$  with EID-SCE. The ultimate goal to be finished with correct semantics management is to meet all the individual

criteria of completeness, consistency and no redundancy as a whole.

- Formalization with knowledge from mathematical conjunctures, e.g. “infinity” from Cantor, etc. We believe that the hints from some mathematical conjectures and theories may well fit some purposes of complexity control of modeling processes at least at theoretical level.

\* Full or on the fly implementations of above initiatives can be adapted to specific need. The concrete implementation of computation is by way of  $\langle$ classification(CLA), order(ORD) $\rangle$

\* For possible<sub>maybe unconscious</sub> [3] negative reader: we are afraid of readers who is not really self guaranteed about their semantics and expressions of the (Y/N)|(T/F) about their argumentation of the content of this draft. Obsess: what should we expect to continue as a topic if they are really guaranteed about the above criteria.

## 2. Related Problems collection and analysis

### 2.1 Issues in the category of (theoretical vs. engineering)

Hypotheses: There is a distinct/ultimate gap among theoretical vs. engineering. Engineering practice could map to limited computation while theoretical description could deal with unlimited and abstract topics.

Theoretical criteria for semantics:

- $\langle \rangle$  (\*extreme complete)
- Consistency
- No redundancy
- $\langle \langle \rangle$  , Consistency , No redundancy  $\rangle$

\* Probability inference is taken as an exception temporarily.

\* “Experience” based inferences could never be theoretically accepted.

### 2.2 Completeness (independent of human) of semantics

We propose that the formal criterion of the ideal ultimate semantics: It is complete or independent of human [17] subjective explanations or it is objectively recognized/shared by observation and reasoning. Cases for NL semantics: usually NL semantics are explained as notations. They implicitly assume the “same” understandings among the speakers and listeners although this process is often omitted unconsciously. The semantics formalization requires the transformation from unconscious to conscious through explicitly formalizing human side semantics: semantics<sub>humanside</sub>(implicit  $\rightarrow$  explicit).

### 2.3 Obsesses of the manner of definitions

#### 2.3.1 Implicit vs. explicit of semantics

To our knowledge, current practices of giving definitions by human in the form of text expressions do not get out of the mode of “circled definition”. Or they stay in conceptual level by introducing new CPTs to express new CPTs. Please retrospect on “CPT vs. semantics” with self questioning on: whether we have ever expressed a ultimate complete <semantic> with NL at conceptual level? Do we use NL terms only on conceptual level for thought processes? Can we reach an ultimate self conscious or unified understanding of semantics of terms like “knowledge”, “information”, “intelligence”, “computation”, “description vs. implementation”, “complete”, “ENT(entity) vs. REL(relationship)”, “TYPE(type) vs. INS(instance)”, etc, with NL?

Deep analysis: From the start point of processes of giving definitions, part of the semantics is implicit in human side and limited to specific individuals. So part of the understanding of the semantics is implicit in human side. It is not shared as expected in an objective manner which is assumed during the expressing process unconsciously.

Although the approach of given definitions is used in quite a lot of drafts as the start of discussions, it can be concluded from above analysis that from the claimed “formal definitions”: as long as the implicit part of the semantics<sub>|humanside</sub> is not included into the topic of the formalization, no real formal<sub><</sub> can be achieved in the sense of <><sub>EID-SCE</sub>. One of the goals of EID-SCE is to reveal the implicit semantics expressions, complete the expressions and guide them to exceed the expressive limitations of conceptual level.

### 2.3.2 “Infinite” vs. abstraction

There is intense debate among the expression capability of NL with “infinite” vs. abstraction related issues, e.g. entity vs. relationship in ERM, etc. The problem is that no persuasive authorities but non persuasive tradeoffs. For this we propose to introduce theoretical hypothesis and employ hints from acknowledged mathematical findings to guide the execution and explanation of project practices.

### 2.4 Strategy of expression

The strategy which we adopt for expressions concerning the understanding progress of this draft regarding the extent of formalness is a sequence: Informal<sub>NL</sub>—continuously→ formal<sub>EID-SCE</sub>. This synchronizes the understanding process of EID-SCE.

This draft intends to reveal in a decidable manner which is decidable in both OWA and CWA. In this work, the discussion on first principles with NL is also included in the content.

### 3. Expected achievement

### 3.1 Hypotheses

#### 3.1.1 Formal vs. informal

There is no fixed decisions on (Y/N)|(T/F) concerning the priority between them if the concrete evaluation context is missing. The motivation for this work related to them is that: it is time to do formalization which start from a hypothesis on them.

#### 3.1.2 On NL

There is minimum “CORE” for formalizing semantics of NL terms which is ultimate: independent of human subjectivities, originating in the level of worldviews<sub>NL</sub>. Consequently it is not limited to CPT/conceptual level.

On the positive aspect of achieving the negation of this hypothesis: it is equally important to reach either the positive or the negative decision/(T/F) of the content of this hypothesis. It is because that the decision of this hypothesis is fundamental to many strategies which could be developed on it.

We propose that NL expressions can be assumed/used as a target to evaluate a formalization approach in terms of limited to conceptual level or not. If it is valid/capable to formalize NL as a whole, it should be not limited to conceptual level.

#### 3.1.3 On FOL (First order logic)

It is easy to conclude from the above analysis on the manner of definition and completeness of NL terms, FOL is not complete or informal for semantics formalization in view that it need indispensable context. The realization of full explicit semantics/knowledge expression rely on the condition that implicit human side knowledge or (human knowledge)<sub>|implicit</sub> is transformed from implicit to explicit: (human knowledge)<sub>| (implicit→explicit)</sub>.

From EID-SCE view, FOL provides symbols instead of independent complete semantics whose existence does not rely on NL concepts. The usually adopted impression that independent and complete semantics is provided could be revealed as unconscious from the view of EID-SCE. Then what is taken as decidable could be found as no more decidable if the expressiveness is saved as a reference.

#### 3.1.4 On mathematics theories

Some theories from mathematics will fit to the formalization purpose very well such as four color theory, etc.

### 3.2 Complete, consistent, no redundancy

Evaluation<sub>NL</sub> by default: By meeting the requirement on <<>, Consistency, No redundancy > with EID-SCE, the following can be reasonably expected about semantics:

- not limited to conceptual
- explicit decidable

This is implemented with the transformation: (“context”<sub>human side</sub>)<sub>NL</sub> → (extreme formalized/decidable). This is also expected for improvement of the automation levels of model driven engineering (MDE) and model transformation (MT). The successful introduction of the formalization approach will support building ontology of high <reusability/dependability> in a model driven manner. This approach could be flexible to support the on the fly or incremental tradeoff. More consciousness could be achieved from the increased application of transformations: (unconscious → unconscious)<sub>NL</sub> and <“implicit”→explicit>with decidability of (T/F)<sub>EID-SCE</sub>. The extension will be expected to support <integration, validation, remedy, (optimization)><sub>EID-SCE</sub> of other existing theories and experience.

#### 4. Proposed solutions from MDE/MT perspectives

Perspectives which are gained during the practice of model driven engineering (MDE) and model transformation (MT) are used here to gain the insight for analysis purposes here.

##### 4.1 Towards extreme

###### 4.1.1 Necessities

EID-SCE proposes extreme/ultimate in the forms of intuitions. Formal semantics with MT or (semantics<sub>EID-SCE</sub>)<sub>MT</sub> is supposed to be consistent/same with the extreme of proper intuitions if only these intuitions can be consciously achieved but not necessarily to be able to be expressed.

To reach the extreme intuition, it necessities:

- Hypothesis on worldviews like Dualism, etc. (\*NL: Dualism can be recursive to others.)
- Modeling human (vs. machine) to enable conscious, (→explicit), and completeness, hence after.
- (methodologically enable formalize NL semantics )

All these have been considered in EID-SCE.

###### 4.1.2 Compatibility

Feasibility/practical of EID-SCE is shown as that it is compatible to all kind of logics as long as they try to stand consist with intuition and consciously.

Situations which do not fit directly: it is because deliberate vagueness is needed. But indirectly EID-SCE also fits positively with these situations since that it can aid this purpose indirectly with:

- Guide/plan the strategy of deliberate vagueness

- Validate the proposed vagueness and redundancy with certain meters such as amount of gaps among Y/N and T/F flows or CWA/OWA flows[20, 21, 22].

#### 4.2 Filling the missing link (Cognitive model (CM))[3]

To realize semantics<sub>humanside</sub>(implicit→ explicit), EID-SCE proposed to model human as ROLES during the communication processes [13]. The key ideas include below:

- <ROLE><sub>MT</sub>: During the application process of EID-SCE, it is important to be always cautions or stay conscious with the proper MTs of ROLES.
- Revelation of “context sensitive” situations which claim that formalization is bounded always with necessary additional information or unknown contexts. This is implemented with formalization of human knowledge in the mode: implicit→ explicit.

For NL expressions: “semantics<sub><</sub> vs. semantics<sub>NL</sub>” differs in whether the transformation processes of (semantics<sub>implicit/human side</sub> → semantics<sub>explicit</sub>)<sub>NL</sub> → semantics<sub><</sub> are implemented.

#### 4.3 Elementarily applying EID-SCE to NL/logic connectives

##### 4.3.1 “AU¬A ”/ “ A∩¬A ”

Example (various logic)/NL expressions: “AU¬A”/ “ A∩¬A ”

(various logic)/NL → various semantics  
 := *undecidable of various situations*  
 : conflict  
 : inconsistency  
 : incomplete  
 : unnecessary redundancy/overlap  
 : vagueness  
 : gap (\*integration)  
 : null

The semantics decidability from EID-SCE views:

- For NL term “A” with backgrounds:

Informally the decidability of Y/N is influenced by the validation on the claimed consciousness or conscious<sub>(?)</sub>. The accomplishment of transitions of context<sub>implicit→explicit</sub> results in acceptable/(decidable). The neglect of transitions of context<sub>implicit→explicit</sub> results in unacceptable/(undecidable).

- From the view of “time”[3] of EID-SCE evolution:

“A” vs. “¬A” is not guaranteed at the same level/time of the EID-SCE compatible semantics in the circumstances of different expression purposes. It is possible that the expression “A” owns a specific complete semantics which is bounded specially with the state of “A” prior to expression “¬A”. This

condition could be omitted in general NL expressions. Then when the expression of “¬A” is introduced under discussions, the semantics which is bounded to “A” need to be changes or updated to be proper for the correctness of the discussion.

The expression of “¬A”: if the expression is justified as valida, it will justify the related  $\langle Y/N, T/F \rangle_{|EID-SCE}$ . Y/N is for the meaning of what A denotes, and T/F is bounded to “¬”. If the expression is not justified for its specific semantics properness, from the views of backgrounds OWA vs. CWA it could be extends as follows: if the CWA is adopted, “¬” is valid/legal: CWA:  $\rightarrow$ : “¬A”:  $\rightarrow T_{|EID-SCE}$ . Otherwise OWA is adopted, “¬” is invalid/illegal: OWA:  $\rightarrow$ : “¬A”:  $\rightarrow F_{|EID-SCE}$ . The expression of “ $A \cup \neg A$ ”/ “ $A \cap \neg A$ ”:  $\rightarrow F_{|EID-SCE}$ .

### 4.3.2 Quantifier symbols $\forall$ and $\exists$

From the view of EID-SCE, decidability of “ $\forall$  and  $\exists$ ” is partially related to decidability of ““A”<sub>default expression</sub> and “¬””. Elementary discussion: T of “A”<sub>default</sub> relies on T of “ $\exists$ ”. This can be mapped to EID-SCE(t1). T of “¬” relies on the conformation T of “ $\forall$ ” or CWA. This maps to EID-SCE(t2).

### 4.4 Towards integrating logics

EID-SCE is expected to supports integrations of logics for semantics management from the backgrounds of  $\langle CWA, OWA \rangle_{|EID-SCE}$ :  $\rightarrow \langle Y/N, T/F \rangle_{|EID-SCE}$

#### 4.4.1 On deductive reasoning

- “Deductive arguments are said to be valid or invalid, never true or false.” [11]

This argumentation actually functions as introducing new CPTs of “valid”/ “invalid” which differs from the T/F in an implicit manner. It is implicit because that by introducing new CPTs which leaves the space of difference but not guaranteed as long as the explicit semantics| $\triangleleft$  is absent or the process of semantics|<sub>implicit/human side</sub>  $\rightarrow$  <sub>explicit</sub> is not finished.

A remedy from (Y/N)|(T/F) of EID-SCE: map “valid” to Y, and map “invalid” to N. For (Y/N) vs. (T/F), with time|<sub>EID-SCE</sub>,  $Y/N_{|EID-SCE}$  (or semantics|<sub>human side</sub>)—(prior to)  $\rightarrow T/F_{|EID-SCE}$

- Revelation on a classical example

“An example of a deductive argument and hence of deductive reasoning: All men are mortal. Socrates is a man. (Therefore,) Socrates is mortal”

“All”/  $\forall$  :  $\rightarrow$  can referred as above explanations, its decidability requires mapping to specific situation/time|<sub>EID-SCE</sub>. Theoretically discussion: assuming T/F of expression (“all men”) simultaneously acknowledges the corresponding situation/time|<sub>EID-SCE</sub> which related to a CWA. Another assumption: “mortal” implies a decidability of (Y/N)|(T/F) for the CWA. The expression revelation in whole:

$(\langle Y/N \rangle / \langle T/F \rangle) : \rightarrow (Y/N) / (T/F) : \rightarrow (Y/N) | (T/F)_{|EID-SCE}$ . There is no preference on: “(Therefore,) Socrates is mortal”. It is| $\triangleleft$  one of the variation of  $(Y/N) | (T/F)_{|EID-SCE}$ .

#### 4.4.2 On inductive reasoning

“beyond the confines of our current evidence or knowledge to conclusions about the unknown.” [12]

From the perspectives of EID-SCE or perspective|<sub>EID-SCE</sub>, the content of above expression embodies an implicitly decision backgrounds transformation from CWA towards OWA: CWA  $\rightarrow$  OWA. It is the essence that characters inductive reasoning.

#### 4.4.3 Unification by way of revelations

Revelation functions as specifying on guiding:

- Classification/(CLA)
- Priority/order(ORD)

\* In EID-SCE, CLA and ORD are hypothesized as two parts exclusively composing computation :  $\langle CLA, ORD \rangle :: = \langle CP \rangle / (\text{computation})$

By reducing or refine, every essential action/behavior to  $\langle CLA, ORD \rangle$ , a unification at computation level can be reached.

All these above discussions on formalization criteria and logic variations are supposed/expected to be fundamental to the description and implementation during the modeling process of the 3D semantics reconstruction processes.

### 5. Corresponding directly to requirements in ARCH3D

“How to define an ontology to drive the reconstruction process? How to find semantic objects in a cloud of points? How to control an algorithm in order to find all objects in the cloud of points?” [1]

#### 5.1 On “How to define ontology to drive the reconstruction process?”

Ontology driven reconstruction processes are actually application of semantics/knowledge driven processes while ontology fits the need of automation and reusability in contrast to human interactions.

Define ontology: EID-SCE supports developing and validating ontology as well in a systemic manner. While as described before on definition, EID-SCE avoids using definitions. EID-SCE especially fits driving the reconstruction process as it can be adapted to cater a development process by constructing an ontology which is organized in accordance to process features.

## 5.2 On “How to find semantic objects in a cloud of points?”

EID-SCE is expected to support this process in both a forward and a backward manner, and their combinations which is guaranteed by the time/ORD of EID-SCE.

- Forward manner:

∠: it supports construct lower level target semantics objects in a complete manner as long as that completeness is reached in a previous level. The subsequent data investigation/algorithms can be scheduled or predicted on what expected/target objects is going to be revealed.

For complexity of objects: “*Today, computer-driven evaluation of spatial data sets is limited by the complexity of the objects to be extracted*”, the construction process with EID-SCE can be expected to be implemented in a layer by layer manner which guarantees a steady semantics complexity expansion.

The semantics complexity control is expected to contribute to the objects complexity control in a multiple layered hierarchy. Benefit will expected related to efficiency and accuracy.

- Backward manner:

∠: it supports construct higher level organizational target semantics objects in a complete manner. The subsequent data investigation can be scheduled with the expected/target objects. The construction can be expected to be implemented in a layer by layer manner which guarantees a steady abstraction(ABT) control.

- Combination manner:

Real engineering practices usually involve the integration of the two manners to reach the most beneficial tradeoff.

## 5.3 On “How to control an algorithm in order to find all objects in the cloud of points?”

Since that the ontology which drives the process will be constructed to provide both the static structure of the semantics needs to retrieve the data features and possibly the dynamic mechanism which caters the process of the algorithm, it is safer to acknowledge the achievability of the algorithm. Inversely the algorithm can be controlled/manipulated with the modification on both the static and dynamic contents of the ontology.

Direct functional or quality solutions: One important working direction is that semantics organization/computation related to functional implementation or quality evaluation of building objects allows efficient direct solutions to functional or quality concerns in 3D reconstruction requirements of Archi3D projects.

## 5.4 Dealing with “redundancy, incompleteness and noise within the clouds of points” [1]

EID-SCE is expected to contribute to avoid/eliminate objects redundancy, incompleteness and noise by ways of semantics redundancy in the following manners.

- Avoid semantics redundancy during the semantics composing operations of EID-SCE
- Maintain the completeness which is supposed to be reachable by inheritance from a higher level application of EID-SCE.
- Find/validate semantics redundancy and incompleteness of existing works by EID-SCE. It could be used to schedule a modification hence after.
- Noise(“noise, *the erroneous points and irregularities in the wall*”) *could be defined/identified strategically by interacting on findings of above works.*

## 5.5 Tracing objects in a reconstruction process by semantics computation

“... during various processing steps and their inevitable data exchange..., semantic information and object structures are lost.” [1]

Objects tracing is expected to ensure a complete and coherent information updating. This tracing is expected to be resembled/synchronized by corresponding semantics modification.

A set of rules of semantics modification are expected to be found out to automatically support the semantics modification in accordance to the changes of objects.

Functional vs. quality: The targets of this process are not only geometrically correct, but also semantically consistent with the functional/quality expectations of the requirement of the modification plan of buildings.

Quality information: it relies on the introduction and retrieving on professional civil engineering knowledge. Complexity of rules: “*As a matter of fact it is complicated and time consuming to formulate rules in order to detect and extract objects geometrically correct.*” [1]

The rules are expected to be automatically drivable with the support of ontological information. To be ideal, the semantics rules can also reflect the weaving of multiple concerns which occur during the planning of the reconstruction. We would like to call this process as “semantics computation” supported “objects computation”. The ideal complete final result of this semantics computation will cover not only the semantics related to the architecture objects and their functional/quality compositions, but also the control process of the process of these direct implementations.

## 5.6 On relatively reaching “a higher conceptual level” vs. surpassing conceptual

“...model the semantics of knowledge as well as the structure where this knowledge is stored, it is necessary to reach a higher conceptual level. For that, knowledge representation is independent of knowledge use.” [1]

Relativity of a comparative “higher conceptual level”: if the expression method is by way of NL, circled expression will be found out theoretically after a short or long exploration. The semantics boundary of NL guarantees an ABT relativity/equality of “conceptual” in contrast to the semantics<sub>human side</sub>. EID-SCE is designed to reveal/express semantics surpassing the conceptual level.

## 5.7 On validation and design/expression of a clearer strategy than NL

This is an initial illustration which is applied on validation and expression of an existing strategy description of image registration.

Original expression: “image registration procedure: feature detection, feature matching, mapping function design, and image transformation and resampling.” [14]

The revelation is initially practiced by explicitly revealing the implicit content of the semantics with the introduction of the <ROLES> of EID-SCE.

- Feature detection

The semantic<sub>implicit→explicit</sub> part of this process can be mapped to “semantics<sub>OBS</sub> → semantics<sub>AUTR</sub>” of the implicit part of original semantics. The focus is from observation to initial identification. It is implicit CLA.

- Feature matching

The semantic<sub>implicit→explicit</sub> part of this process can be mapped to “semantics<sub>AUTR</sub> → semantics<sub>READER</sub>” of the implicit part of original semantics. The focus is building “equal”/“:=” (vs. “!=”) / “is-a” relationships. It is an implementation of (Implicit CLA) → (Explicit CLA)

- Mapping function design

The semantic<sub>implicit→explicit</sub> part of this process can be mapped to “semantics<sub>READER</sub> – semantics<sub>AUTR</sub>” → semantics<sub>READER</sub>” of the implicit part of original semantics. The focus is building phenomenal “equal”/“=”/“is-a” relationships, while the direct link to semantics<sub>OBS</sub> has been not necessary or lost/(independent). ABT can be created here. It is implementation of (Implicit/explicit) ORD → (explicit CLA).

- Image transformation and resampling

The semantic<sub>implicit→explicit</sub> part of this process can be mapped to the combination or iteration of “semantics<sub><ROLES></sub> → semantics<sub><ROLES></sub>” of the implicit part of original semantics. Some phenomena are impossible to trace or identified if a semantics link is broken/(ABT). It is implementation of composition((Implicit/explicit) ORD → (explicit/implicit)CLA).

Experimental results of completeness analysis by EID-SCE:

- “(Implicit/explicit) CLA → (explicit/implicit)ORD” is absent?
- Is it a possible gap to be filled to ease the process?

## 5.8 On application with OWL, SWRL, etc.

Corresponding optimization approaches of <description (DES), implementation (IMP)> aspects on NL and logics has been proposed in previous sections. Since that these optimization contents are fundamentally important to OWL, SWRL, etc, it is reasonable to expect subsequent optimizations influence on applications of OWL, SWRL, etc.

## 5.9 Strategy of application of EID-SCE

- Indirect decidable for expression: Since the expressions here are supposed to be towards Formal<sub>EID-SCE</sub> but not finished in the sense of directly decidable for expressions.
- Direct decidable for validation: It is decidable in the sense of validating the incompleteness of the object expressions, and leaves spaces for optimization hence after.
- Quality control: EID-SCE is not complex but necessary for formal expression. EID-SCE supports reducing the existing cases towards more efficient structures. EID-SCE supports validating existing cases in the sense of tradeoff of <<>, consistency, no redundancy>. EID-SCE refines NL semantics towards the minimum core, and it synchronizes with progressing of semantics reuse.

## 6. Feasibility discussion

A glance of the implementation of ideas such as (Y/N) flow can be found in Figure1 which shows the control flow activity diagram for 3D objects identification.

### 6.1 Backgrounds discussion concerning feasibility

Hypothesis: People know what NL is? (It is not guaranteed. They can do self checking about this with EID-SCE.)

- The project rely on NL
- The project does not rely on NL.



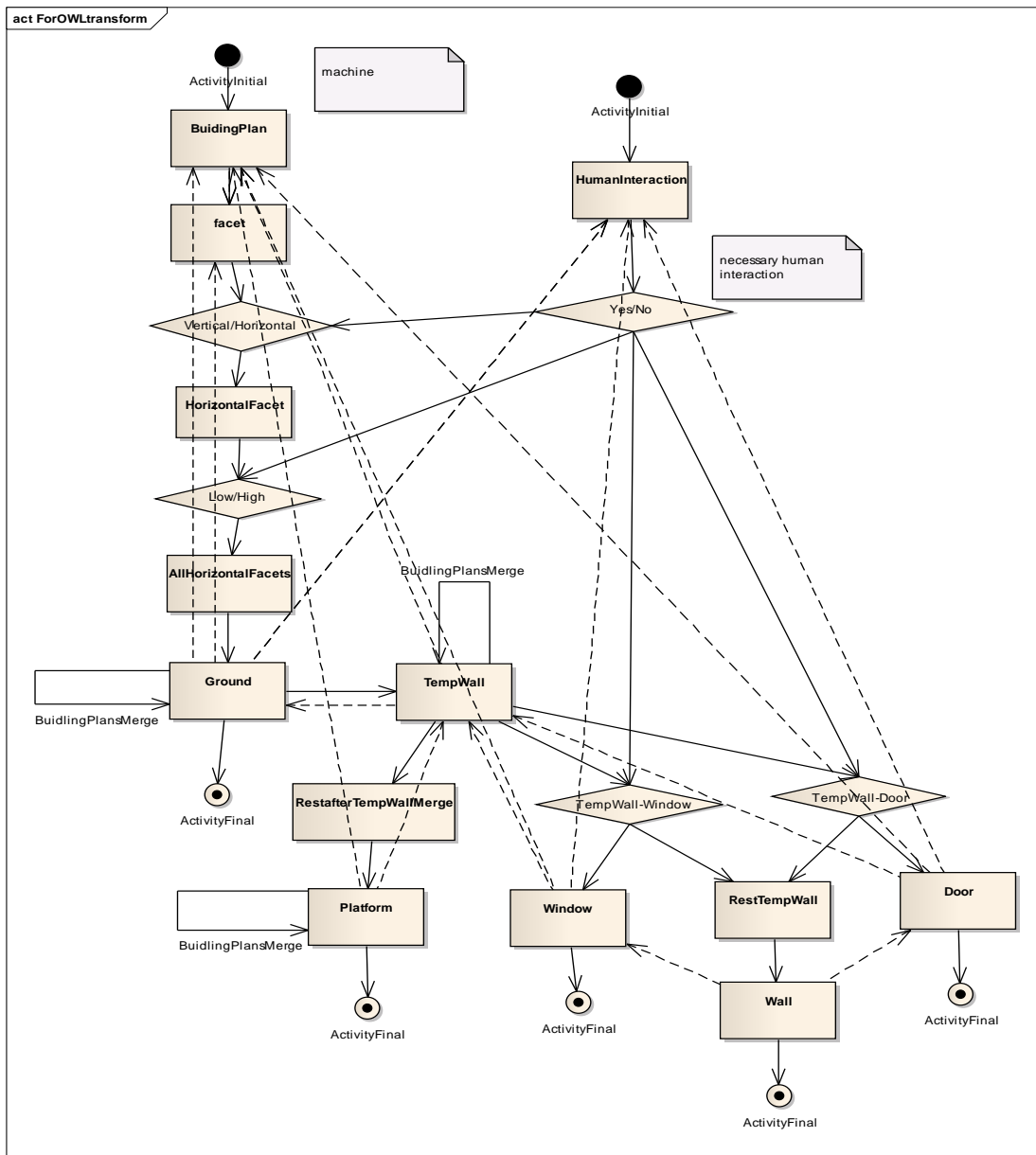


Figure 1. Illustration of the control flow activity diagram for 3D objects identification.

Analysis: This draft fit well for the Y of the first situation. The draft appears to do not fit to the Y of the second situation. It actually does fit (if they do not get alternations of EID-SCE), because the “not rely” is an unconscious reply. If they do not get alternations of EID-SCE or no ultimate formal semantics are achieved, EID-SCE is needed for the process of “informal → formal” in the manner of ultimate.

### 6.2 About “incomplete information” obsession

EID-SCE avoids the “incomplete information” obsession at the expression level. (\* “incomplete

information”: → EID-SCE expression stays with <<, →, no redundancy> (\*<<, →, no redundancy> --guarantee → <> .) .)

### 6.3 NL ambiguities vs. (Y/N)|(T/F) with the content

For the content here in this draft, ambiguities originate in NL are supposed/expected to exist as the tradeoff result of expression strategy. So the (Y/N)|(T/F) argumentations concerning is meaningful only if they are expressed with EID-SCE. And the only inconsistency will come from the mistakes made during the process of the deduction or validation unconsciously.

### 6.4 Validation: peer review vs. model checking

From what is stated in section IV, it is safe to conclude that only peer reviewing is needed to guarantee the mistakes made during the implementation process by human negligence. But no traditional model checking is needed because that the semantics and notations/syntax are unified and coherent at inside and among various ABT levels.

## 6.5 Expressive vs. decidability

With EID-SCE semantics, it is going to show that “robust decidability and ease of implementation” does not necessarily come at a price of missing entailments, i.e. of incompleteness. It is because that EID-SCE semantics supports both completeness and decidability as a whole. What is considered controversial can be revealed with applying EID-SCE to the NL form problem expressions.

## 7. Some related works

Bijan [4] states that “even seasoned logicians and knowledge representation experts find description logics perplexing, misleading, and simply confusing, especially when it comes to what they can or cannot express.” Guarino N [15] has intuitively proposed an investigation on conceptual level. Ontological level functions successfully in playing a role of empirically aggregating/CLA and delimiting/ORD concepts alternative to formalization, in accordance to a domain (\* In contrast to commonly assuming terms in ontology bear better/(comparative) commonsense/understanding/semantics, we prefer that there are no evidence/proof from EID-SCE so far. They are equally identified as NL terms, except that the deliberate classification into ontology.). But from the content and the adopted strategy and the addressing strategy, e.g., “introduced an ontological level between the conceptual level and the epistemological level”, it seems that his differentiation is still limited to the scope of NL conceptual. This draft is not going to follow the mode of introducing an intermediate/relative level to ease the problem in the sense of CLA while it essentially just transfers or decomposes problems instead of directly solving them. We have identified these problems in general as fundamental initiations, EID-SCE has been proposed to reveal and solve this. Great minds since the era of Aristotle, e.g., Frege, Kant, Russell, Wittgenstein, Quine, etc. have proposed continuously successful progressions to related topics (\*e.g., Frege's logic [16] extends Aristotle's logic to be capable on inferences from Euclid's geometry towards indefinitely complex mathematical statements.). For this project we appreciate their works on the very insightful intuitions. Our solution based on EID-SCE is going to be a practice which applies to the integration of semantics MTs with 3D reconstruction processes to gain efficiency and reliability, etc.

It is clear to conclude from the previous sections that there maybe some solutions/alternations which equal EID-SCE in the sense of formalization in extreme, but none of them are expected to be better. Consequently it is capable to validate other theories and approaches for whether they have really met their expected/claimed objectives, such as “remaining decidable”, etc. in a scientific manner.

## 8. A short summary

We aim at developing a method to contribute to the whole process of Archi3D project by investigating and optimizing the semantics of Archi3D models based on SWRL, OWL, and RDF, etc. fundamentally. The automatic MTs among SWRL, OWL, unary/binary first-order logic and RDF, etc. at various ABT levels are also expected as a consequence of the unification/integration process.

The system still proposes to retain the storing mechanism with the existing database management systems and consider geometry as one of the major data types. Moving on, we suggest use of collaborative web platform semantic web technologies and knowledge management to handle the information by several archaeologists and technicians, etc. The platform will be able to store data during the excavation and manage them with the knowledge acquired during the 3D objects identification process. Furthermore, it will facilitate the collaborative interaction process between archaeologists and the platform to generate knowledge from the data sets. In the future [18], we are going to refine the ideas and implement the refined solution in more detailed practices [20, 21 and 22].

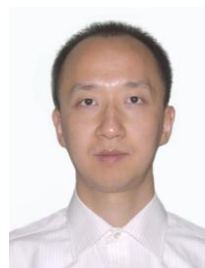
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