Spatial Awareness for the Deafblind in Natural Language Presentation using SPIN Rules: A Use Case in the SUITCEYES Platform

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Presenter

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Short Resume:

- Researcher at the Centre of Research and Technology Hellas (CERTH) on Internet of Things (IoT) and Semantic Web technologies
- PhD student at Aristotle University of Thessaloniki on the topic “Big Data Management and Analytics”

Background

- Currently an estimated 2.5 million people with deafblindness are living in Europe. Due to the increasing life expectancy and the aging population, this number is forecasted to rise substantially by 2030 [1]
- Communication with and between users with deafblindness is constrained by the medical nature of this disability, ranging from congenital to acquired deafblindness, including worsening sight or worsening hearing or both over time, plus, ultimately, symptoms of ageing as well [2]
- Limited research on deafblindness and related issues as opposed to blindness issues.
- The main challenges of users with deafblidness are:
  - Perception of the environment
  - Communication and exchange of semantic content
  - Learning and joyful life experiences
- More and more IoT applications are used for healthcare purposes due to their high interoperability and expressiveness [3][4][5]

Related Work

IoT applications that acquire knowledge from multiple sources and from continuous and heterogeneous data flows

- ACTIVAGE [3]
- Knowsense [4]
- Dem@care [5]

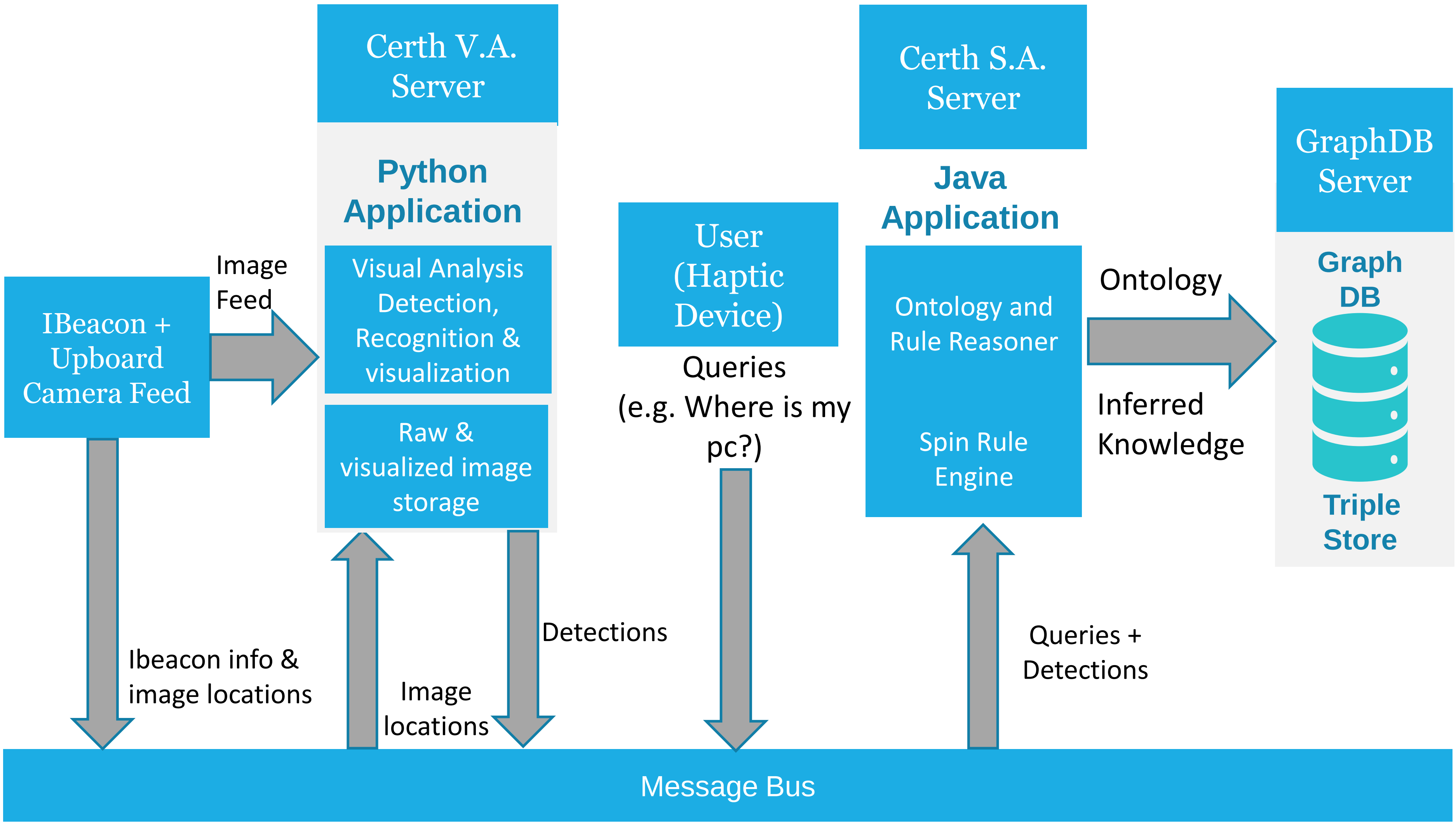
Ontology-based frameworks for language processing

- Linguistic ontology of space for natural language processing [6]
- Natural language processing using ontologies [7]

Natural language processing with SPARQL query language and SPARQL Inferencing Notation (SPIN)

- Natural language sentences to SPARQL framework [8]
- Evaluation of SPARQL and SPIN in data quality problems within the Semantic Web [9]

System Architecture



User Communication Process

HIPI triggered by user → VA & iBeacon data → Ontology → Haptograms → Actuators

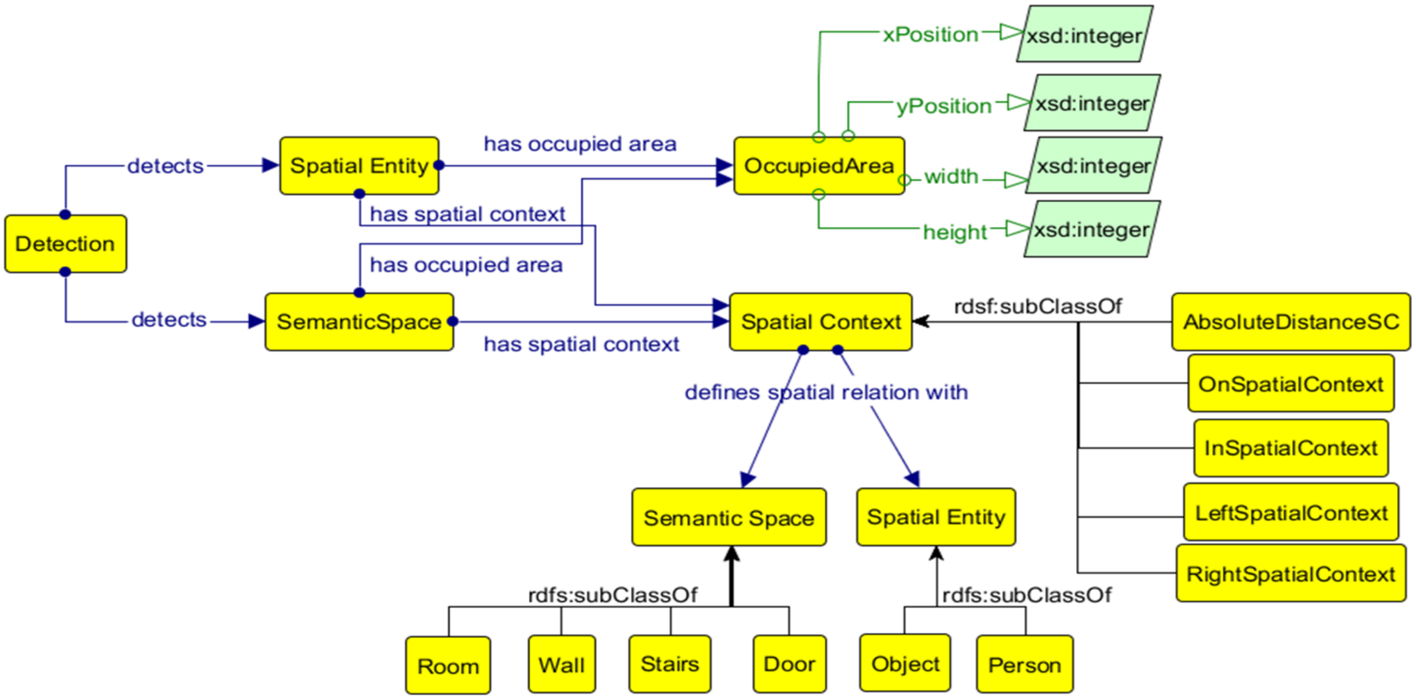
The process:

- Optic sensors (cameras), provide the ontology with data (object/person locations, timestamps, etc) through Visual Analysis (VA) algorithms as detections
- Deafblind user draws queries on haptic device (e.g. “Where is my laptop”)
- Query is processed by the Semantic Analysis Component (SA component), which returns an answer in natural language (e.g. “Your laptop is on your right side, very close to you)
- The answer is then translated into haptograms that reach the user as vibrations on actuators on wearables like vests

The scope of our work includes only the SA component

The Ontology

- We use and extend the ontology of the SUITCEYES project [10]
- The ontology contains Object, Person and Semantic Space (mostly rooms) classes
- We focus on the part of the ontology related to **spatial awareness** presented in natural language



Differential Population

- We implemented a process that allows only detections with **new** information to be inserted in the ontology
  - E.g. if a detection with a laptop is detected **twice** in the same **same place**, only the timestamp of the **first** detection is updated. The **second** detection is **not** populated in the ontology.
  - This process greatly **decreases the volume** of the data stored in the ontology, as many objects don't change place frequently.

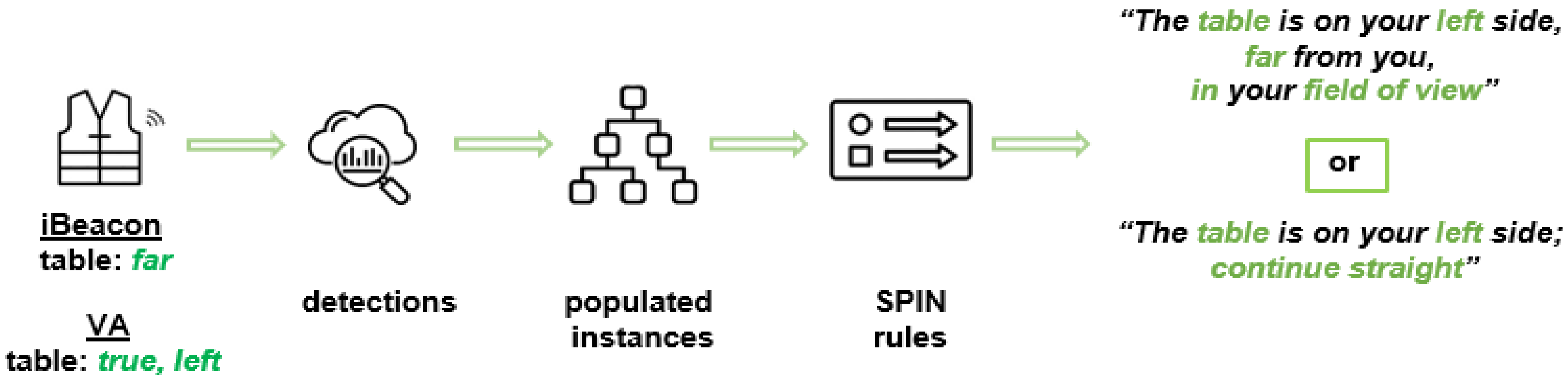
Procedure: Differential Population
Data: D (Detection type object obtained from message bus)

---

for *each* D_i *stored in ontology* **do**
    if $D.detects\_object == D_i.detects\_object$ *and* $D.spatialContext == D_i.spatialContext$ **then**
        D_i.timestamp = D.timestamp;
    end
end

From concepts to phrases

- SPARQL Inferencing Notation (**SPIN**) [11]: Established standard to represent SPARQL **rules & constraints** on ontology-based models



Dataset

- We created a synthetic dataset including objects (laptops, chairs, etc) and spatial relations between them (close to, right from, etc). This dataset is based on the entities that exist in the SUITCEYES project
- Then, we executed queries that an actual deafblind user would ask, like “Where is my laptop?”, “How many objects are close to me?”, “Where am I now located?” and other similar queries
- We present some of the rules and answers that were provided in the following slides

Examples with SPIN rules and functions (1/2)

- Query: “Which <objects> are <close to> me?”
  - In <> we put parameters, e.g. <objects> can be replaced with <people> and <close to> with <far from>
  - Query answer provided by Protégé[12]

```
WHERE{
    BIND (sospin:Function_SelectLatesObjectDetection() AS ?detection) .
    ?detection a sot:Detection .
    ?detection sot:detectsObject ?object .
    ?detection sot:detectsObject ?object2 .
    ?detection sot:detectsObject ?object3 .
    ?object a ?object_type.
    ?object2 a ?object_type.
    ?object3 a ?object_type.
    ?object rdfs:label ?objectName .
    ?object2 rdfs:label ?objectName2 .
    ?object3 rdfs:label ?objectName3 .
    ?object sot:hasSpatialContect ?spatialContext.
    ?object2 sot:hasSpatialContect ?spatialContext2.
    ?object3 sot:hasSpatialContect ?spatialContext3.
    ?spatialContext a ?spatialContextType .
    ?spatialContext2 a ?spatialContextType2 .
    ?spatialContext3 a ?spatialContextType3 .
    ?spatialContextType rdfs:SubClassOF sot:Spatialcontext .
    ?spatialContextType2 rdfs:SubClassOF sot:Spatialcontext .
    ?spatialContextType3 rdfs:SubClassOF sot:Spatialcontext .
    FILTER ((?spatialContextType - sot:CloseSpatialCOntext) &&
        (?spatialContextType2 = sot:CloseSPatialContext)  &&
        (?spatialContextType3 = sot:CloseSPatialContext)).
    BIND (sospin:Function_CloseFarContext(?spatialContext) AS ?closefar_annotation).
    BIND (BNODE() AS ?output) .
    BIND (CONCAT(?objectName, ", ", ?objectName2, "and a ", ?objectName3, ", are ", ?closefar_annotation, "to you. ")
        AS ?description).
}
```

queryOutput	textualDescription
QueryOutput	"A Laptop, a Chair and a TV are close to you"^^<http://www.w3.org/2001/XMLSchema#string>

Examples with SPIN rules and functions (2/2)

- Query: “Where is my <laptop>?”

```
CONSTRUCT{
    ?detection sot:producesOutput ?output.
    ?output sot:refersToDetection ?detection.
    ?output a sot:Output.
    ?output sot:hasTextualDescription ?description .
}
WHERE{
    BIND (sospin:Function_SelectLatesObjectDetection() AS ?detection) .
    ?detection a sot:Detection .
    ?detection sot:detectsObject ?object .
    ?object a ?object_type.
    FILTER (?object_type = sot:Laptop).
    ?object rdfs:label ?objectName .
    ?object sot:hasSpatialContect ?spatialContext.
    ?spatialContext a ?spatialContextType .
    ?spatialContextType rdfs:SubClassOF sot:Spatialcontext .
    FILTER ((?spatialContextType - sot:RightSpatialCOntext) || (?spatialContextType =
sot:LeftSPatialContext)).
    BIND (sospin:Function_LeftRightContext(?spatialContext) AS ?leftright_annotation).
    FILTER ((?spatialContextType - sot:RightSpatialCOntext) || (?spatialContextType =
sot:LeftSPatialContext)).
    BIND (sospin:Function_LeftRightContext(?spatialContext) AS ?leftright_annotation).
    BIND (sospin:Function_CloseFarContext(?spatialContext) AS ?closefar_annotation).
    FILTER ((?spatialContextType - sot:CloseSpatialCOntext) || (?spatialContextType =
sot:farSpatialContext)).
    BIND (sospin:Function_CloseFarContext(?spatialContext) AS ?closefar_annotation).
    BIND (BNODE() AS ?output) .
    BIND (CONCAT(?objectName, "is on your", ?leftright_annotation, " side.", ?closefar_annotation, "to you.
") AS ?description).
}
```

object	description
Laptop	"Your Laptop is on your right side, close to you."^^<http://www.w3.org/2001/XMLSchema#

Conclusions

Our framework provides spatial awareness to people with deafblindness, using natural language and semantic reasoning with SPARQL/SPIN notation

- The framework was tested using synthetic data from the SUITCEYES platform
- The differential population process greatly decreases the volume of the data

Future Work

- Two phases:
  1. Framework test with real, live data provided by sensors
  2. Framework test with deafblind users

Thank you for your attention!

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