CONTEXT-AWARE PROCESSING OF CONTINUOUS LOCATION-DEPENDENT QUERIES IN INDOOR ENVIRONMENTS

MOVE - DELFT MEETING - NETHERLANDS - STSM SESSION

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TALK OUTLINE

1. RESEARCH CONTEXT
   - Location- and context-aware services and queries in indoor environments
   - Research challenges

2. SUMMARY OF RESULTS
   - A hierarchical and context-dependent indoor data model
   - Continuous query processing architecture
   - Query language for navigation-related queries in indoor environments
   - Continuous processing of location-dependent queries

3. DISCUSSION
   - Activities and achievements during the STSM
   - Research perspectives
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Context-aware indoor navigation services exploit context dimensions in order to

- anticipate user’s needs
- customize the user’s experience

Many components that contribute to the design of a context-aware system should be reflected by the spatial model underneath
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Location-dependent queries (LDQ) comprise requests triggered by the user to “pull” some location-dependent information about objects of interest
- Position queries
- Navigation queries
- Range queries
- K nearest neighbour (kNN) queries
RESEARCH CHALLENGES

- Developing a context-dependent indoor data model that
  - represents the features that populate the environment along with their dynamic properties
  - supports a large spectrum of services and queries (at different levels of abstraction)
**RESEARCH CHALLENGES**

- Developing a context-dependent indoor data model that
  - represents the features that populate the environment along with their dynamic properties
  - supports a large spectrum of services and queries (at different levels of abstraction)

- Designing a continuous query processing architecture for LDQs in indoor environments
- Introducing a query language to improve expressiveness of navigation-related queries
- Developing algorithms to process continuous navigation, range, and nearest neighbour queries in indoor environments
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A HIERARCHICAL AND CONTEXT-DEPENDENT INDOOR DATA MODEL
CONTINUOUS QUERY PROCESSING ARCHITECTURE

SQL-like query

User

System interface

Generating an SQL-like query

Parsing the query

Rewriting and analysing the query

Is route computation required?

Query execution engine
- Update queries with the locations of relevant objects and with the new set of relevant routes, if needed
- Execute standard queries
- Correlate results of standard queries
- Present the answer

Generating standard queries

Route manager
- Refine candidate routes based on updated edge weights
- Maintain the set of relevant routes up-to-date

Distribution manager

Graph & context data

Graph & context data

Graph & context data

Graph & context data

Cancel?

yes

no

Phase 1

Phase 2

Phase 3

Phase 4

Phase 5

Phase 6

Phase 7

yes

no

stop
Query language for navigation-related queries in indoor environments

General query structure

Query \rightarrow (Standard-query | Navigation-query)

Navigation-query \rightarrow select \( (Attr-Projections | '*') \) from All-routes-expression \( ('Class-names') \) (with Stop-vertices) ? (where Conds) ? (optimization-criteria) ?

All-routes-expression \rightarrow All-routes \( ('Loc-Ref', 'Loc-Target') \)

Loc-Ref \rightarrow Object-id ('.'coord') ? | \( gr ('Map-id', 'Object-id') \) | \( gr-map ('Map-id', 'Gr-id') \) | Vertex-id

Loc-Target \rightarrow Class-name | Object-id | Vertex-id ('.'coord') | \( gr ('Map-id', 'Class-name') \)

Location-dependent conditions

LDQ-Cond \rightarrow inside \( ('Args-Inside') \) | nearest \( ('Args-Nearest') \) | ...

Args-Inside \rightarrow Radius \( ('Loc-Ref', 'Loc-Target') \)

Args-Nearest \rightarrow K \( ('Loc-Ref', 'Loc-Target') \)

Example of a navigation query: Find the shortest route from person ‘userID1’ to person ‘userID2’, showing the results at the room level:

```
SELECT gr('room-level', RO.id)
FROM Person AS P1, Person AS P2
All-routes(gr('micro', P1), gr('micro', P2)) AS RO
WHERE P1.id = 'userID1'
AND P2.id = 'userID2'
MINIMIZE length(RO)
```

Example of a range query: Retrieve all the communicating entities in the vicinity (at a distance smaller than 100 meters) of a user identified by ‘userID’ and with a communication range of at least 200 meters:

```
SELECT CO.id
FROM Object AS CO
WHERE inside(100 meters, gr('micro', 'userID'), CO)
AND CO.Communicate = true
AND CO.commRange >= 200
```
PROCESSING OF CONTINUOUS NAVIGATION QUERIES

STEP 1 → STEP 3: HIERARCHICAL PATH SEARCH

1. Find the optimal path within the initial granule until reaching the nearest exit.
2. Search at the abstract level for the optimal path from the exit of the initial granule to the granule containing the target object.
3. Find the optimal path within the last granule to the target object starting from the corresponding entrance of the granule.
PROCESSING OF CONTINUOUS NAVIGATION QUERIES

STEP 1 → STEP 3: HIERARCHICAL PATH SEARCH

1. Find the optimal path within the initial granule until reaching the nearest exit
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STEP 4: CONTINUOUS PROCESSING OF THE QUERY

4. Step 4 starts a continuous path search by taking into account updated locations of reference and target objects (considering moving targets)
   1. Transform an initial search tree rooted by the previous $v_{start}$ to an updated tree rooted by the current $v_{start}$
   2. The algorithm continues either by expanding new sub-trees from the leaves towards the target and/or by removing sub-trees that are no longer needed
PROCESSING OF CONTINUOUS RANGE QUERIES

1ST ITERATION: HIERARCHICAL NETWORK EXPANSION

1. Perform a *hierarchical* network expansion in all directions around the reference object.
2. Keep all visited nodes along with pointers to their parent nodes as well as weights to the source node.
PROCESSING OF CONTINUOUS RANGE QUERIES

1ST ITERATION: HIERARCHICAL NETWORK EXPANSION

1. Perform a *hierarchical* network expansion in all directions around the reference object.

2. Keep all visited nodes along with pointers to their parent nodes as well as weights to the source node.

CONTINUOUS PROCESSING OF THE QUERY

3. Update the set of parent nodes when changing the root of the sub-tree (i.e., when the reference object moves).

4. Boundary nodes are checked to decide, for each of them, whether to further expand this node or to perform a reverse search towards the source to remove nodes that are not relevant any more.
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Activities and achievements during the STSM

Main contributions

- An extension of the hierarchical and context-dependent indoor data model
- A generic architecture to process continuous location-dependent queries in indoor environments
- A continuous indoor-based query language for location-dependent queries
- Hierarchical and incremental algorithms applied to both static and moving objects are proposed for continuous navigation and range queries
**Main Contributions**

- An extension of the hierarchical and context-dependent indoor data model
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**Personal Experience**

- Opportunity to learn about location-dependent query processing
- Many fruitful discussions with Dr. Ilarri from University of Zaragoza, Spain
- A fruitful collaboration : Jaise paper (submitted)
CURRENT AND FURTHER WORKS

- Studying existing platforms that favour network-based data models and allow querying moving objects over spatial networks (e.g., Secondo, LOQOMOTION)
- Analysing the efficiency and scalability of the solutions proposed to deal with continuous location-dependent queries
RESEARCH PERSPECTIVES

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IMPLEMENTATION REQUIREMENTS

- An extensible DBMS that supports
  - developing network-based data models
  - new algebra (i.e., specific data types and operations)
  - implementing algorithms for LDQ processing over moving objects
- Continuous query processing architecture: could integrate a simulator of moving objects
Thank you very much for your attention!
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