Situational Awareness for Manufacturing Applications

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Introduction

We describe a system capable of continually tracking the state of an environment to support the development of a robotic assistant for industrial assembly tasks.

Primary Objectives

- Create a centralized representation of the state of an environment
- Track 32 DOF human poses within the described world

Main Contributions

- Database-style system supporting a novel timestamp handling model.
- Human tracking capable of detecting and resolving self and mutual contacts

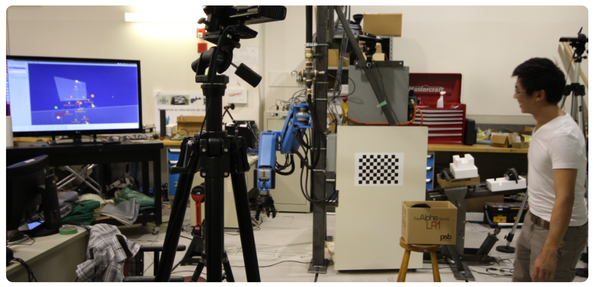

Figure 1: Worker looking at rendered state of the world

Situational Awareness

A situational Awareness Database (SADB) system was developed to maintain a representation of the world state.

Architecture

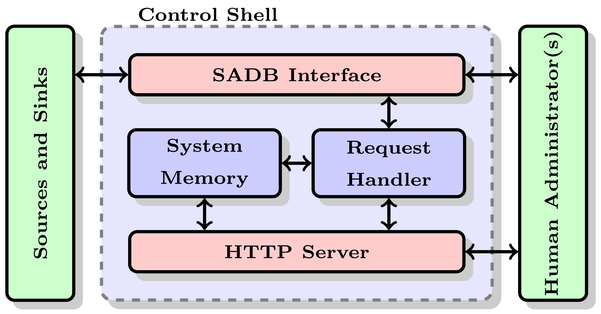

Figure 2: Simplified block diagram of the SADB architecture

Key Features

- Explicit timestamp representation
- Real-time operation

Semantic Data Organization

Categorized data can be queried through standard mathematical set operations.

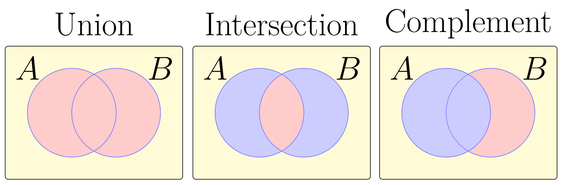

Figure 3: Venn-diagram representation of the three basic query functions, with selected region in pink.

Performance Evaluation

DB System	Local (μs) Read	Local (μs) Write	Network (μs) Read	Network (μs) Write
SADB	1321	942	10095	11668
Redis	932	1073	10118	11967
MongoDB	348812	2927	3742027	11375

Table 1: Average read and write times for 3 database systems

3D Human Pose Tracker

Figure 4: Four Kinect depth images are merged and segmented to obtain a foreground point cloud

Contact problem

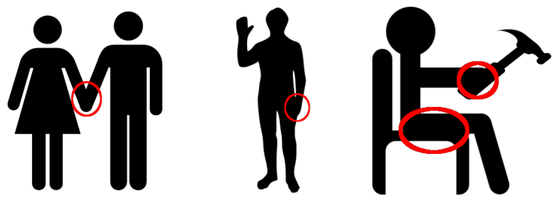

Figure 5: Three types of contact classes

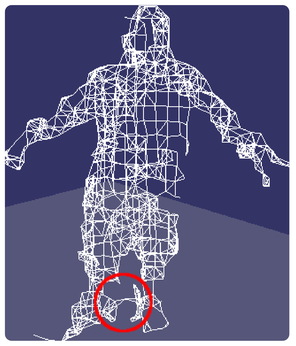

Figure 6: Geodesic distance graph with an invalid edge

An optical flow voting scheme is used to label each point.

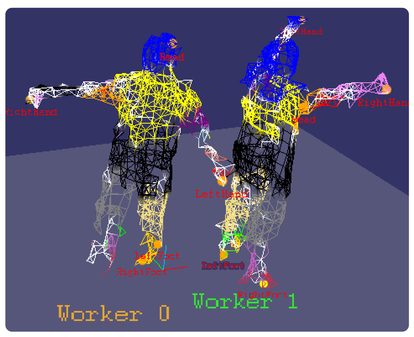

Figure 7: Points labeled by optical flow

The geodesic distance graph is updated to remove edges with non-compatible labels.

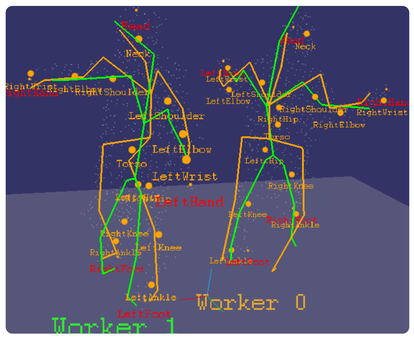

Figure 8: Extracted skeletal pose with reference Vicon skeleton

Case Study

Test platform simulates realistic working environment for a car door assembly task.

Figure 9: Workspace with 4 Kinects

The most important values tracked by the system for safe interaction are:

- Worker Position
- Worker Pose
- Worker Gesture
- Handover Location
- Task State

Conclusion

We have presented a general-purpose system capable of leveraging sensor networks to maintain a consistent representation of an environment and of the humans within.

Additional Information

- `www.cim.mcgill.ca/~apl/database/sadb/`
- `{aphan2,ferrie,olivier}@cim.mcgill.ca`

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