Orientation-Aware Artifacts

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**Motivation**

Invisibility and ubiquity are key objectives in pervasive and ubiquitous computing.

Technological advances enable integration of sensors in everyday artifacts
- MEMS technology + ad-hoc wireless communication technologies

How to use such artifacts for interaction?
- What information can be acquired about artifacts (self-description)?
- Our focus: artifacts which are aware of their orientation

Why orientation?
- Changes through manipulation of artifacts
- Enhances description of movements and static states in euclidean space
- Different types of orientation
- Opens up a plethora of application scenarios
- There are many open issues
Orientation Sensors Overview

State-of-the-Art

Fields of Application
- Context-aware computing
- Mobile computing
- Distributed computing
- Human computer interaction
- Augmented and virtual reality
- Automotive computing

wireless 3DOF orientation tracking supports up to 4 cubes per receiver integration of 10 sensor elements
- 180Hz update rate
- 1200°/sec max. angular speed
- 6-9V battery
- 31.2 mm x 43.2 mm x 14.8 mm

wireless 3DOF acceleration tracking based on Analog Devices ADXL2XXJE
- 1kHz update rate (all three channels)
- ±10g, shock limit of 500g
- 3.6V Li-Ion AA size internal battery
- 25 mm x 25 mm x 5 mm
Gesture Recognition Framework

3 categories of gestures

<table>
<thead>
<tr>
<th>Category</th>
<th>Timing</th>
<th>Type of object</th>
<th>Dynamics of movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand of the user</td>
<td>Continuously</td>
<td>Hand</td>
<td>High</td>
</tr>
<tr>
<td>Object the user holds permanently</td>
<td>Continuously</td>
<td>Artefact (small)</td>
<td>Static-high</td>
</tr>
<tr>
<td>Object manipulated occasionally</td>
<td>Occasionally</td>
<td>Artefact (large)</td>
<td>Static-low</td>
</tr>
</tbody>
</table>

\[ G_n \equiv (\text{object}, \text{name}) \]

Framework for orientation sensor-based gesture recognition

- Core component: gesture library which contains an application-independent set of gestures
- Independent of sensor technology / classification methods
- Acommodates a variable number of sensors
- Provides composition of elementary gestures

Gesture Recognition Framework

Framework for orientation sensor-based gesture recognition

Composition Module
- Detect gestures which are composed from multiple elementary gestures

Sensor 1a  Sensor 1b  ...  Sensor m

Sensor module 1  ...  Sensor module m

Sensor API

Gesture Library

Sensor module

Model information
Physical objects
Training data

Gesture data
Raw data

Sensor API

Classifier

Trainer

Composition

Gesture API

Application 1  ...  Application n

Application 1

Detection module
Detect gestures which are composed from multiple elementary gestures

Sensor module

Model information

Gesture library

Classifier

Trainer

Composition

Gesture API

Application 1

Composition Module
- Detect gestures which are composed from multiple elementary gestures
Application Scenario: Smart Home Environment

Lights are on if and only if person is walking

Steer video-projection on the wall with relaxation chair
Unlock the computer for authorized persons sitting in front of it

Control video-player
(one artifact for discrete and continuous control)
Application Scenario: Universal Turning Knob

Idea: replace common turning knobs with a „universal turning knob“

Features:
- Connection automatically established by spatial proximity to controllable device
- Authorization by unique ID of the context knob (“key-functionality”)
- Generates control signals of types on/off, multistage and continuous, whose meaning depend on the device to which the knob is connected (“turning knob-functionality”)
- Feedback on controlled device (e.g. integrated display) and/or via the turning knob (e.g. integrated vibrator)
- Embed biometric sensor for authenticating the user to the turning knob?
- Wearable, affordable, personalized
Towards Self-X Artifacts

To enable interaction, artifacts have to describe themselves
- Describes the artifact’s properties, interests, capabilities
- XML-based self-description, context-dependency, …

To enable autonomy, artifacts have to manage themselves
- Process controlling the behaviour of the artifact
- Dynamic rule-based process control, discovery of and communication with artifacts, interaction based on locality / proximity, matching of interests ↔ self-descriptions, …

Self-description and -management are a basis for self-organisation
- Multilateral interaction among a collective of artifacts
- Static / dynamic composition of artifacts, multilateral interest-matching, performance / energy contraints, …

How can spatial orientation and linear acceleration contribute?
- What knowledge can be inferred from static orientation or movements of a collective of smart artifacts?
- How can it affect self-management and self-organisation?
- Can new forms of interaction be found?
Thank you!

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