Position paper for the CSCW 2000 Workshop on “Exploring the Framework of Context Awareness in Cooperative Systems”

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Defining Context

Context sensing in interactive applications refers to the acquisition of information from the surrounding environment. We are interested in the sort of information that can be:

- accessed via sensors that capture properties of real-world phenomena, and
- used to offer application functionality or to modify existing functionality to make it more effective or usable.

The term ‘context’ suffers from an embarrassing richness of alternative definitions. Dey, Salber and Abowd [1] provides a useful review and offers a version that is a useful starting point for our definition of sensed context:

context $=_{def}$ any information that can be used to characterize the situation of an entity, where an entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location, identity and state of people, groups and computational and physical objects.

This definition needs some refinement to capture our notion of sensed context. Sensed context refers to that part of context that comes from the physical environment; i.e., that part of context that is accessible via sensors, in other words, the properties of phenomena. The term ‘phenomenon’ refers to “an occurrence, a circumstance or a fact that is perceptible by the senses.” [2] This term comes close to expressing that set of things we wish to include as the subjects of sensed context information if we take the “senses” to include non-human sensing devices.

The relationship of sensors to phenomena can be related in space-time as shown in figure 1. That is, phenomena “occupy” spatial and temporal locations. Often, occurrences of sensing provide “samples” of the phenomena or special events, such as the boundary of the phenomena in space or time. Many of the interesting design and implementation questions about sensed context relate to the sensor-phenomenon relationship, including the timeliness and accuracy of the sensed information and whether identity of agents or artifacts across phenomena can be determined.

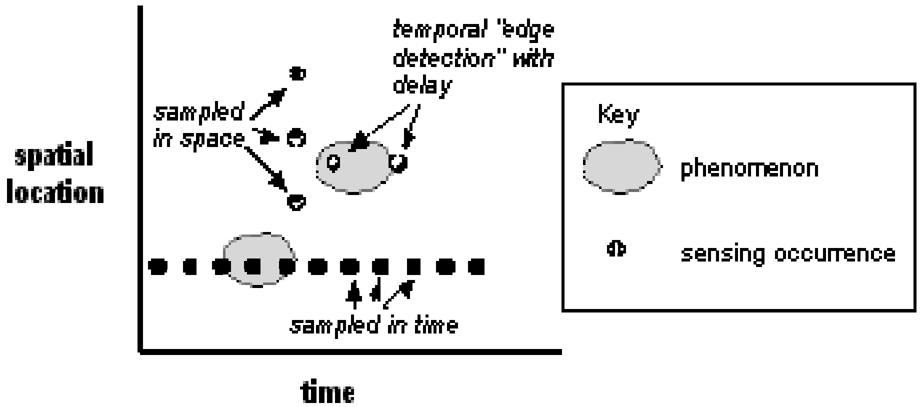

Fig. 1. Relationships of phenomena and sensing activities in space-time. The sensing activity at the bottom is performed by a fixed sensor that provides samples at regular intervals. The phenomenon at the top is sensed twice, but there's a delay in detecting the beginning and the end of the phenomenon, for instance because sensing occurs at fixed intervals.

Building upon this notion of phenomena, we propose the following definition:
sensed context $=_{def}$ information that characterizes a phenomenon, is sensed and that is potentially relevant to the tasks supported by an application and/or the means by which those tasks are performed

Using context typically involves two sets of activities: acquisition, and transformation. Sensed context data is acquired through sensors, without user intervention. The sensed context data however, has a very low level of abstraction. To provide applications with useful context information, several types of transformation may be required. Typical transformations include looking up IDs in a database, converting data to appropriate units, merging and comparing data from different sensor sources, comparing sensed data to historical data, etc. This list is far from exhaustive and may include complex processes such as artificial intelligence rule-based inferences, knowledge discovery, machine learning, etc.

Some Dimensions for Context Sensing in Cooperative Systems

One of the distinguishing features of sensed context information, compared to other sorts of information utilized in an application, is the importance of the way it is acquired. Sensors are subject to failure and noise. Often, they only capture samples of phenomena, hence their output is approximate only. Furthermore the process of interpretation of sensed context is also subject to ambiguity and approximation. In addition, sensors may be used in conjunction with actuators that perform actions in the physical world.

These aspects are sufficiently important that we propose that a framework for context-aware cooperative systems should encompass meta-attributes of the sensed information, including:

- forms of representation (e.g., units for numerical values)
- information quality
- sensory source (e.g., type and location of sensors)

Information quality is a particularly important issue with sensors. We break down this attribute into the following characterizing properties:

- coverage – the amount of the potentially sensed context about which information is delivered
- resolution – smallest perceivable element
- accuracy – range in terms of a measure of the sensed context
- frequency – sample rate; the temporal equivalent of resolution
- timeliness – range of the measure in time; the range of error in terms of the time of some phenomena; the temporal equivalent of accuracy

These properties are perhaps easiest to consider in the case of spatial location. For example, a piece of sensed context might provide its information in terms of a resolution of 100m and an accuracy of +-10%. Similarly, it the information is also temporal, we can identify its form of representation (seconds), its frequency (5 kHz) and its accuracy (or timeliness) (±100 ms).

We believe these are well-defined attributes of quality of all, or at least many interesting, properties of sensed context. They can be determined from the characteristics of the sensors used and the transformations involved.

In addition, cooperative systems highlight privacy and security issues that should be carefully considered. In particular, who owns the context data, and whom the data may be disclosed to should be considered in the framework.

References

1. Dey, A.K., Salber, D., and Abowd, G.D., *A Conceptual Framework and Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications*. Human-Computer Interaction (to appear), 2000.
2. *American Heritage Dictionary, 3rd Edition*.