Works in Progress

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Support for Context-Aware Pervasive Computing Environments

EDITOR'S INTRO

The projects featured in this issue examine the use of context in pervasive computing environments—from a context logger for mobile applications, to a system for building contextualized learning ecosystems, to an algorithm that reduces the complexity of contextual information retrieval.

—*Anthony Joseph*

CONTEXTLOGGER2: A LOGGER CONSTRUCTION KIT

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The smartphone's ubiquity has made it interesting for social sciences. ContextLogger1, which we designed to run on Symbian S60 under the GPL license, was presented in a 2005 issue of *IEEE Pervasive Computing* (M. Raento et al., "ContextPhone: A Prototyping Platform for Context-Aware Mobile Applications," *IEEE Pervasive Computing*, vol. 4, no. 2, 2005, pp. 51–59). Our goal in updating the system was to support larger-scale research. The end result is a logger construction kit that strives for portability by providing basic plumbing-like build and runtime configuration facilities and a data persistence and transport layer (T. Hasu, *Contextlogger2: A Tool for Smartphone Data Gathering*, tech. report 2010-1, Helsinki Inst. for Information Technology HIIT, 2010; www.hiit.fi/publications/reports). The logger daemon runs invisibly in the background. The developer can choose the system that best matches the libraries they want to use to implement sensors, and we provide implementations of some event-driven components for different event systems (currently libev, Qt, and Symbian native).

The current code base contains everything required for deployment on Symbian S60 3rd edition and higher, which in 2010 accounted for 44.3 percent of the smartphone market. The logger embeds a Lua runtime with access to status information and dynamic parameters, and the logged data itself goes into a queryable database. Developers can use any language capable of exporting functions in a C or C++ compatible way. Presently, we're improving integration with the Symbian^3 release and are working on portable sensor implementations based on Qt Mobility APIs.

ContextLogger2 is published as open source under the MIT license. Source code and a selection of binaries can be found at www.contextlogger.org.

TOUCHING THE KNOWLEDGE: CONTEXTUALIZED PERVASIVE LEARNING ECOSYSTEMS

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The use of pervasive smart learning objects and services to create contextualized learning ecosystems can enhance both the learning outcomes and the motivational states of students interacting with them using personal mobile devices. The Gradient group at the Carlos III University of Madrid is working on the Learn3 project: "Towards Learning in the Third Phase" (TIN2008-05163/TSI), for defining, implementing, and validating immersive, contextualized, pervasive learning environments as a deployment of the *Internet of things* into learning ecosystems.

A contextualized learning ecosystem should orchestrate the use of three technology-enhanced components: pervasive learning objects, pervasive learning services, and proactive learning environments. Appropriate combinations of technology enablers such as RFID tags, mobile devices, and pervasive service items can create learning environments in which users interact with pieces of knowledge embedded in communicating smart objects and contextualized services. Users of mobile personal devices equipped with appropriate technologies such as Near Field Communications (NFC) can consume the information provided by pervasive

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(either passive or active) learning objects. The information consumption process can be interactive, either through the communication link with the pervasive learning object or through an external representation of such an object in the Internet. Learning services provide additional learning capabilities such as projection rooms, printing services, or collaborative information sharing to the learning environment. The use of such services would simplify the assimilation of concepts and the acquisition of practical competencies. Finally, a pervasive learning ecosystem should also allow accidental learning to take place in a user-friendly manner. Proactive learning environments should provide smart, contextualized, and user-adapted learning information when needed without requiring the user intervention.

The Learn3 project is implementing scenarios combining pervasive learning objects, services, and proactive environments. Tagged objects such as an NFC-tagged telecommunication exchange, touching notes and books, NFC-tagged rooms, offices, and touching campus information points are combined with touching assessment services, NFC-enabled printers, and overhead projectors inside user-tracking and contextualized proactive information recommender environments.

The project is currently evaluating several case studies to assess the impact of these pervasive learning ecosystems both in the incremental learning outcomes and in the improvement of motivational states of the students.

DIMENSIONALITY REDUCTION IN CONTEXT-AWARE SYSTEMS

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The representation of context and the retrieval of information based on that context is, in many ways, a holy grail for ubiquitous computing. Context ontologies, as previously employed, are difficult to create and usually require a manual approach. Moreover, they're normally fixed once defined for a particular problem domain. Vector-based approaches allow for more flexibility because vectors can be defined in multiple dimensions and augmented by further additions of context atoms. However, in determining an information item's relevance or importance in context, the weighting of vector atoms is limited to static weights, which are usually empirically derived. The stativity of weights is counterintuitive to the notion of context as a dynamic, ever-changing feature set. In both approaches, the retrieval of information items in context is difficult because the complexity of performing similarity searches between current context and the relevance of information items is computationally significant.

We propose an adaptation of the FastMap dimensionality reduction (DR) algorithm (C. Faloutsos and K.-I. Lin, "FastMap: A Fast Algorithm for Indexing, Data-Mining, and Visualization of Traditional and Multimedia Datasets," *SIGMOD Record*, vol. 24, no. 2, May 1995, pp. 163–174) as a potential solution to the problems of determining appropriate context features to describe information items and determining the weighting of these features in context. DR in simple terms is the recursive projection of each dimension d_i of an n-dimensional space onto another dimension d_j of a new k-dimensional space (where k is a practical number for visualization, for example, 2 or 3). This technique significantly reduces the computational complexity of vector-based similarity searches. It also naturally clusters similar items and thus can provide an excellent basis for visual 2D or 3D mapping of information. We believe this can greatly enhance the retrieval of personal information items on mobile devices, as their storage capacity and the variance of interrelated information items (SMS messages, email, pictures, documents, and so on) grows ever larger.

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