Ambient Intelligence:

From Sensor Networks to Smart Environments

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Vision offers rich information about events involving human activities in applications from gesture recognition to occupancy reasoning. Multi-camera vision allows for applications based on 3D perception and reconstruction, offers opportunities for collaborative decision making, and enables hybrid processing through task assignment to different cameras based on their views. However, the inherent complexities in vision processing stemming from perspective view and occlusions, as well as setup and calibration requirements have challenged the creation of meaningful applications that can operate in uncontrolled environments. Moreover, the task of studying user acceptance criteria such as privacy management and the implications in visual ambient communication has for the most part stayed out of the realm of technology design, further hindering the roll-out of vision-based applications in spite of the available sensing, processing, and networking technologies.

Smart environments are spaces that sense, perceive, and react to the presence, commands, or observed events of their occupants through a variety of interfaces and offer services such as multimedia, home control, or pervasive communications, as well as accident detection and well-being applications. The notion of *ambient intelligence* refers to endowing such systems with unobtrusive and intuitive interfaces as well as mechanisms to learn and adapt to the behavior models and preferences of their user in order to offer context-aware and customized services tailored to the user needs.

A *user-centric* design paradigm in creating vision-based applications considers the user acceptance and social aspects of the intended solution as part of the design effort. Adaptation to the user's set of preferences and behavior model, seamless and intuitive interfaces, automated setup and configuration, ease of use, awareness of the context, and responsiveness to the user's privacy options are some of the attributes of a user-centric design.

The output of visual processing often consists of instantaneous measurements such as location and pose, enabling the vision module to yield *quantitative knowledge* to higher levels of reasoning. The extracted information is not always flawless and often needs further interpretation at a data fusion level. Also while quantitative knowledge is essential in many smart environments applications such as gesture control and accident detection, most ambient intelligence applications need to also depend on *qualitative knowledge* accumulated over time in order to learn user's behavior models and adapt their services to the preferences explicitly or implicitly stated by the user. Proper interfacing of vision to high-level reasoning through a *context interface layer* allows for integration of information arriving at different times and from different cameras, and application-level interpretation according to the associated confidence levels, available contextual data, as well as the accumulated knowledge base from the user history and behavior model.

Novel opportunities in application development for smart homes, offices, seminar rooms, automotive, health-care and well-being domains, and experience sharing in *social networks* are enabled by employing contextual data and user-centric approaches. A few examples of application development based on the mentioned concepts will be discussed.