Context-Aware Healthcare Robotic System: Architecture and Case Study

Kun Wang

Dept. of Systems and Computer Engineering, Carleton University

Contributor: *Peter X. Liu*

Carleton UNIVERSITY
Canada's Capital University

NSERC CRSNG

Abstract

Context-aware technology has been widely utilized in mobile distribution computing systems in the areas of user-guide, monitoring service, etc. This poster presents a basic layered and centralized system architecture for the context-aware healthcare robotic system. Based on the architecture, a mobile robot, using the local & remote sensors and human direct input, could sense the necessary healthcare-related contexts from surrounding environment and target patient. From these contexts, the environmental and patient situation could be monitored and proper decision could be inferred. Then corresponding tasks are executed by the mobile robot. A case study using visual context is performed based on the system architecture. The proposed context-aware healthcare robotic system architecture could be extended and modified to include more context-sensing, more advanced context reasoning & inference and more complex task execution. Therefore, it could be utilized in other assistive healthcare-related applications.

Concept of Context-Awareness

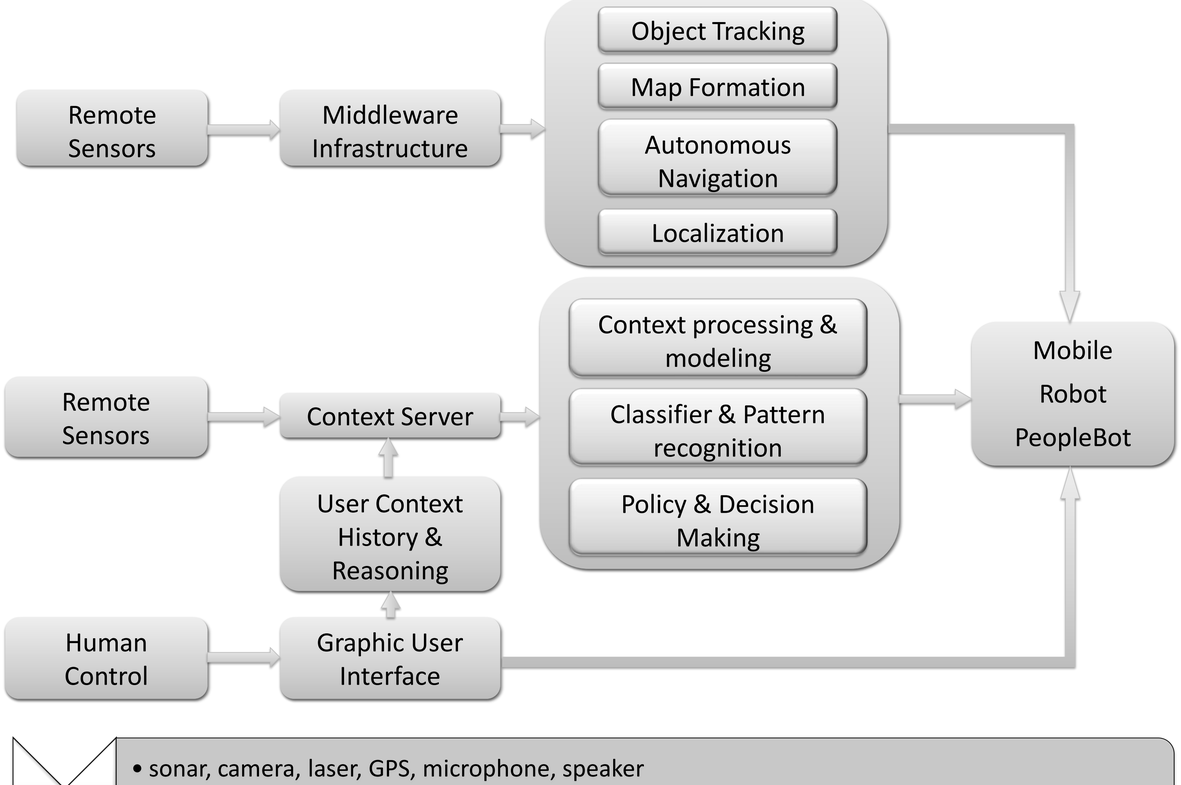
The most accurate and general definition till now is from Dey et al.:

Context is any information that can be used to characterize the situation of entity where entity is a person, place or object considered relevant to the interaction between user and application including user and application themselves.

Again, Dey et al. gives the definition of context-awareness:

A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task.

Context-Aware System Infrastructure



Context-Aware Healthcare Robotic System Architecture

Local Sensor
- sonar, camera, laser, GPS, microphone, speaker
- facilitated by the implementation of middleware infrastructure

Remote Sensor
- medical signal: ECG, EEG, heart rate, pulse, etc.
- auxiliary signal: temperature, light, humidity, thermal condition, etc.

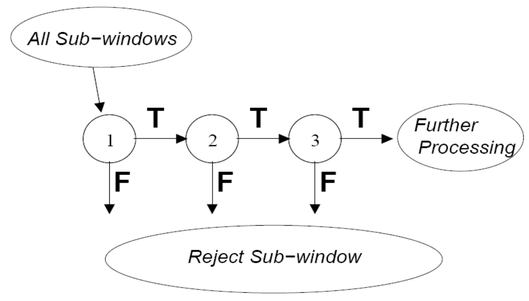
Human Control
- used as the original status, e.g. the intention of the target person, or in some emergent situation
- aroused by the idea of shared-control mechanism

Harr Feature Detection Algorithm

- Using "Integral Image" to detect feature fast
- Constructing a classifier based on *AdaBoost*, which consists feature f_j, threshold θ_j, parity p_j, sub window x

$$h_j(x) = \begin{cases} 1 & p_j f_j < p_j \theta_j \\ 0 & otherwise \end{cases}$$

- Combining successive classifiers in a cascade structure



Particle Filtering (PF) Method

Given all the past and current observations, how to estimate the current target state, in other words, how to construct the Probability Density Function $p(x_k|Z_{1:k})$, by two steps:

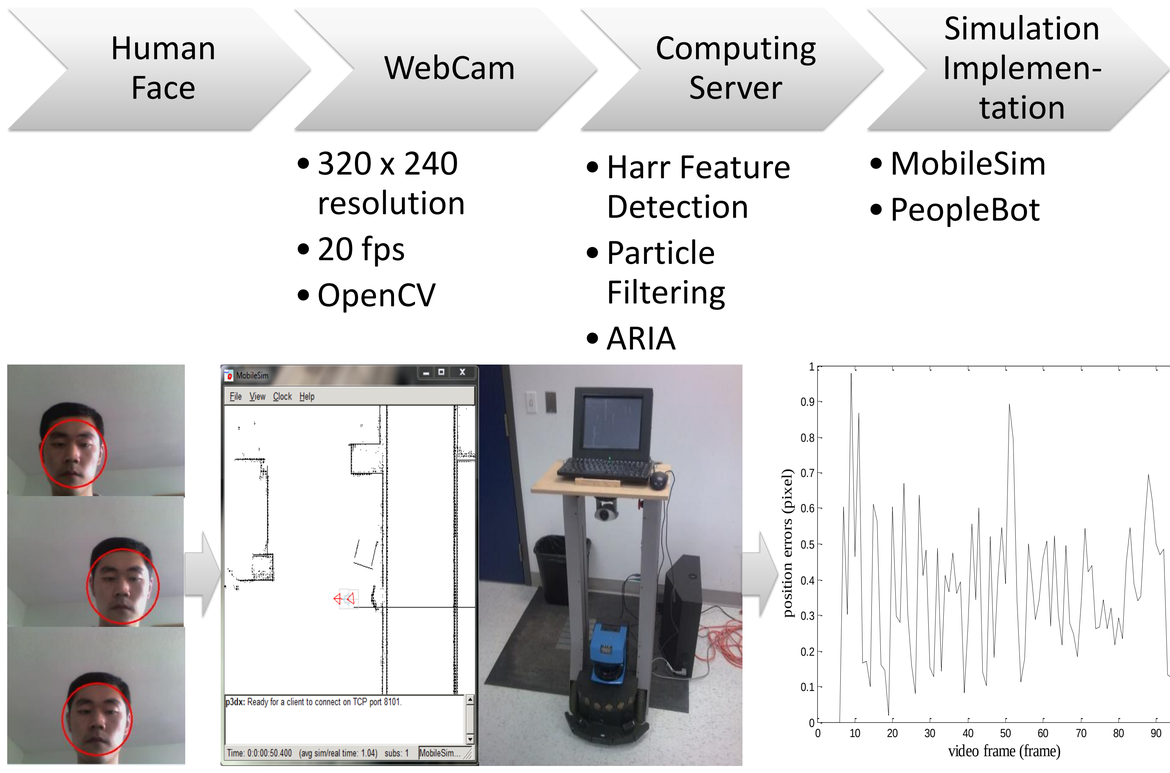
$$x_k = f_k(x_{k-1}, v_k)$$
$$z_k = h_k(x_k, n_k)$$

Prediction step: Using pdf $p(x_{1:k-1}|Z_{1:k-1})$ and system dynamic equation to compute the prior PDF $p(x_k|Z_{1:k-1})$

Update step: Using prior $p(x_k|Z_{1:k-1})$ and likelihood function $p(z_k|x_k)$ to compute posterior PDF $p(x_k|Z_{1:k})$

Particle filtering method, known as sequential importance sampling with no functional form, uses a set of weighted samples (particles) to estimate the posterior distribution. Each particle represents a possible state estimation and the corresponding weight describes its possibility

Case Study: Human Face Tracking of Mobile Robot



Conclusion and Future Work

- Modifying the algorithm to obtain more stable and accurate tracking performance.
- Extending the visual context to include other medical-related contexts.
- Perfecting the system architecture to fulfill more advanced assistive tasks.

Acknowledgement

This work was supported by the Natural Sciences and Engineering Research Council (NSERC) and industrial and government partners, through the Healthcare Support through Information Technology Enhancements (hSITE) Strategic Research Network.