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GRUPO DE INVESTIGACIÓN

Healthcare Information Fusion using Context-Aware Agents

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Introduction

- Context aware systems -> complex information systems capable of providing large quantities of information obtained from network sensors with heterogeneous characteristic.
  - They provide effective and non-invasive solutions.
- These systems store and analyze all of the relevant information that surrounds and forms part of the user context.
- The information is usually acquired through sensors located in different Wireless Sensor Networks (WSN).
  - Current trend for displaying information to system users: an arrangement of distributed heterogeneous systems and WSN.

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Introduction

- Multi-agent systems have been studied recently as monitoring systems.
  - Predicting potentially dangerous situations and managing the physical and cognitive assistance of each person.
- Multi-agent systems facilitate the design and development of home care environments and improve the services currently available, incorporating new functionalities.
- They add a high level of abstraction regarding to the traditional distributed computing solutions.

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Introduction

- Practical problems in the user context:
  - Diversity of characteristics (observable parameters, temporal and sample scales, means of acquisition, etc.)
  - High level of dynamism.
- DATA FUSION can improve the perception of the context information and solve some of these problems.
  - To widen the observational space.
  - To increase the contextual and temporal coverage.
  - Reduce ambiguities.
  - To supplant any shortcomings in any individually considered contextual observation.

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Introduction

- This article presents the HealthCare Context-Aware Computing (HCCAC) multi-agent architecture, which is capable of supervising and monitoring persons in healthcare contexts.
  - The goal of HCCAC is to provide solutions for the wellbeing of its users, by incorporating itself indistinguishably into their daily lives.
- HCCAC integrates CBR-BDI agents that are capable of learning beyond their initial knowledge, interacting autonomously with their environment.
- HCCAC uses the Services laYers over Light PHysical devices (SYLPH) platform.
  - SYLPH is based on a Service-Oriented Architecture (SOA) model for integrating heterogeneous Wireless Sensors Networks (WSNs) into HealthCare systems.

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Introduction

- The communication between the agents and the devices takes place with wireless technologies like ZigBee.
- Radiofrequency Identification (RFID) is used for identification.
- These technologies provide the structure that is required for supporting the communication needs for the system agents with devices and data handling equipment.
- Integration and interaction between intelligent agents, sensors and devices -> integration of HCCAC architecture and SYLPH.

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Background and Problem Description

- Multi-Agent HCCAC system which receives a variety of different information from multiple sensor networks managed by the SYLPH platform.
- The multi-agent system combines the information received into an integrated data base in order to better handle the information and more effectively act on the network sensors.
- HCCAC system has two fundamental tasks:
  - to integrate a known set of data sources that refer to a diagram of individual data.
  - to generate a new unified diagram, based on individual diagrams, that is complete, summarized and comprehensible

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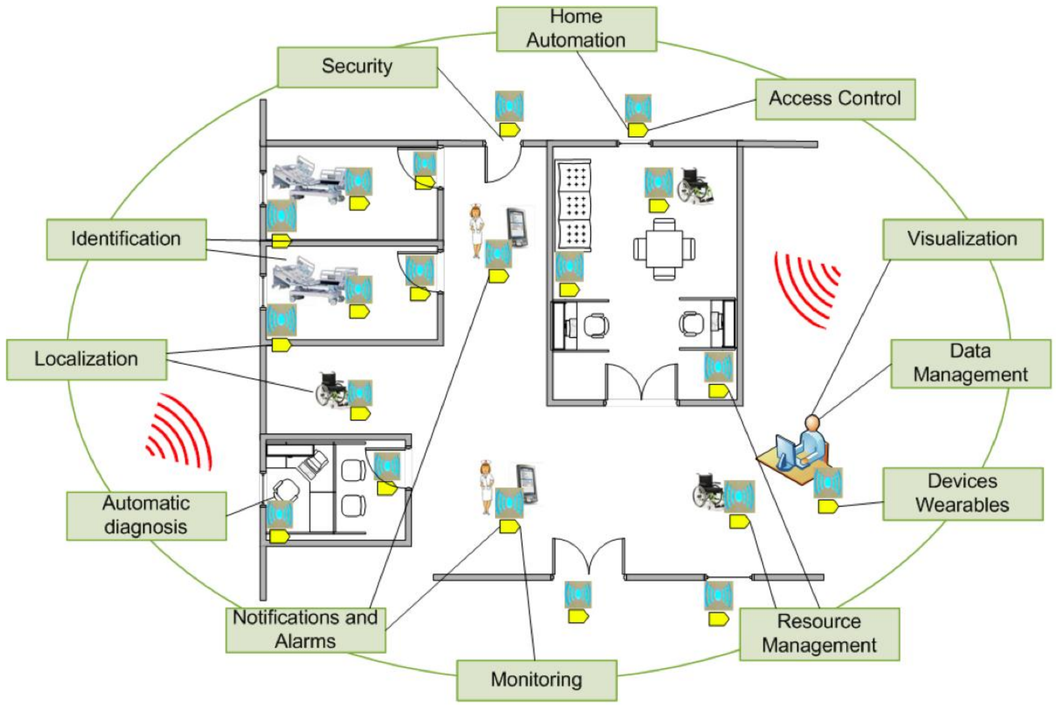
Background and Problem Description

- Recent years have given way to a number of multi-agent architectures that utilize data merging to improve their output and efficiency.
  - There are data fusion models that obtain an optimized and efficient diagram, but few systems attempt to combine information fusion with information gathering components.
  - Those that have attempted, do so through the union of two systems that have been developed independently.
- One step further: to capturing information from multiple sensor networks, equip each agent with data fusion capabilities so that they can structure the information.

Heathcare Monitoring System

- The HCCAC system is based on a multi-agent architecture that is composed of various types of intelligent agents.
- Interpreter Agent: to provide solutions for the wellbeing of the user through the use of action plans based on the information provided by the WSN sensors.
- The most important characteristics of the agent are:
  - The Interpreter Agent has reasoning capability: analyze and reason the context data gathered by the system and provide proactive solutions.
  - The Interpreter Agent can easily adapt to the context within which it acts.
  - Gather sensor data and messages from other agents in order to provide efficient solutions.
  - The Interpreter Agent performs a data fusion with the information received.

WSN at healthcare facility



Basic communication and infrastructure schema of the monitoring system

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Heathcare Monitoring System

- Each of the nodes is controlled by a Provider agent in the HCCAC system.
  - gathering the information from the sensor,
  - applying the first filtering process to the information received,
  - sending the information to the Interpreter agent.
- There is also a computer and mobiles connected to a remote healthcare monitoring center via Internet.
  - This computer acts as device to control the Interpreter Agent and ZigBee master node through a physical wireless interface.
  - The computer is also the master node of a Bluetooth network formed by the sensors working as slave nodes.
  - At the SYLPH level, the computer performs as a SYLPH Gateway so that it connects both WSNs each to other.

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Context Information

- The Interpreter agent performs a detailed analysis of the information that it received in order to generate efficient solutions.
  - The Interpreter agent administers and fuses the information, and distributes tasks among the remaining system agent.
  - Other agents communicate with the Interpreter agent to transmit any changes in the context, tasks, or additional specific user information, which is then updated by the Interpreter agent.
  - The Interpreter agent manages all cases of inserting, deleting and updating each user.
  - It continually calculates the location of the users, informing where each one is located.
  - It is responsible for optimizing the task planning prior to any event that may require a new plan.

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Context Information

- The Interpreter agent has a context-aware belief base in which it stores all events that constitute its knowledge base.
- The beliefs may include:
  - location of the user taken from a RFID chip carried by the user, and transmitted by the location sensors to the system.
  - the exterior temperature captured from web services.
  - the interior temperature gathered from ZigBee temperature sensors connected to the WSN.
  - the illumination gathered from the ZigBee light sensors connected to the WSN.
  - the level of smoke taken from the ZigBee smoke detectors connected to a WSN.

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Context Information

- All of these data are initially captured and filtered by the HCCAC system provider agents.
- The provider agents send this information to the Interpreter agent, which stores and processes it.
- On reception by the Interpreter Agent:
  - accept the information, because it is completely coherent and non-redundant, and therefore useful for reasoning and actions within the environment.
  - reject it because it is duplicate information that the agent already contains and is therefore disposable.
  - refine the information, which is useful but cannot be stored as is, and requires a specific type of processing

Context Information

- Actions are structured through Java objects, which represent beliefs.
- The beliefs base also incorporates the concept of data bases related to objects.
  - The language for queries related to objects, Object Constraing Language (OCL) used in the HCCAC system, can recover subsets of context-aware beliefs.
- Once the condition is satisfied, an internal event is generated, and this event activates a plan or gives way to adopting a new set of objectives.
- In the Interpreter agent, beliefs represent changes in the state of the sensors installed within the context-aware environment.

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Conclusions and Future Work

- Health services established within a healthcare context are based on a close and trusting relationship between the user and the health service.
- These services have to be transparent for the users so that the support offered is imperceptible to the user.
- All of these services can be achieved after passing through a number of internal steps that are hidden from the user.
- One of these steps is the fusion of information gathered from the healthcare context.
- The problem: system truly capable of managing contradictory or redundant data.

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Conclusions and Future Work

- The intelligent agent system presented is capable of generating an integrated and efficient diagram that does not contain duplicated information.
  - The Interpreter agent receives the structured information through the provider agents.
  - The provider agents perform the initial filter of information from the information received through the sensors.
- As a result, the multi-agent system assigns tasks among the different agents so that the process of information fusion is quick and simple, while consuming minimal system resources.
- The next step consists of developing this proposal and implementing it in a real scenario.

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