MONNET : Simulation of the inter-node communication strategy for a network of loosely-coupled nodes in a surveillance application

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Abstract / Résumé

Our project aims at studying the communication strategy between the nodes of the MONNET project in order to maximize the quality of information that is exchanged between the nodes while at the same time minimizing bandpass requirements. The protocol sends pedestrian information only to those nodes which are close visually to its field of view. The communication strategy and its associated protocol are being simulated on the APIA framework developed at CVSL.

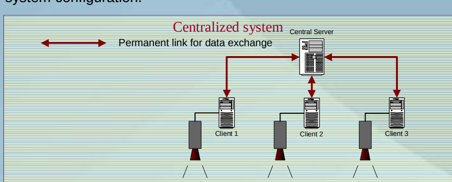
Ce projet a comme principal objectif d'étudier les aspects relatifs aux communications du système MONNET. Pour en arriver à cette fin, nous simulons un tel système à l'aide du cadre logiciel de simulation APIA. L'approche retenue est basée sur les événements se produisant dans l'environnement et vise à réduire le flux de données entre les nœuds du système. Le protocole ne transmet les informations de suivi qu'aux nœuds qui sont situés le plus près dans l'espace visuel même si ceux-ci semblent éloignés dans l'espace physique.

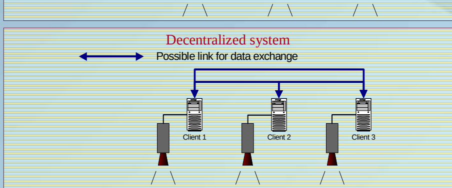
1. Introduction

Tracking people in complex environments is an important problem in many fields: surveillance of public premises, military operations in urban environments, assistance to elderly people in challenging cognitive environments. Our project is part of the MONNET PUL PRECARN project that aims at developing a computer vision based system for tracking people. Our project aims at studying the communication strategy between the nodes in the network in order to maximize the quality of information that is exchanged between the nodes while at the same time minimizing bandpass requirements. The communication strategy and its associated protocol must take into account the fact that nodes may be located « far apart » visually even though they may be located close to each other physically.

2. Related work

Most surveillance systems described in the literature rely on a central server for exchanging information [VSAM]. This solution is not suitable for military operations since the server may go out of service at any time. It is believed that a decentralized system is more suitable for a wide range of applications and offers more flexible system configuration.





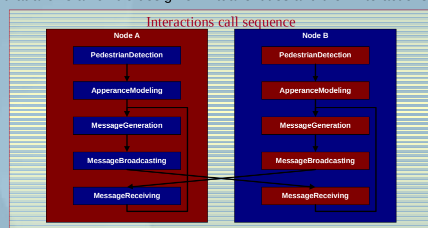
3. Approach

Introduction

The approach consists in defining a scoring mechanism between the nodes which takes into account the information that is received by and send to the different nodes in the system. The communication strategy and communication protocol are being simulated on the APIA simulation framework developed at the CVSL. The poster presents preliminary results of the communication strategy and demonstrates how the loosely coupled network of nodes uses the information exchanged between the nodes to minimize bandwidth requirements.

A. Simulating with APIA

Since the computer vision modules of MONNET are being developed concurrently with our project, we are designing the inter-node communication strategy on a simulation framework. Our project uses a task-oriented simulation framework, namely the Actor-Property-Interaction Architecture (APIA) [APIA]. APIA implements a new paradigm named Interaction Centric Modelling that allows a flexible design of virtual entities and their interactions.

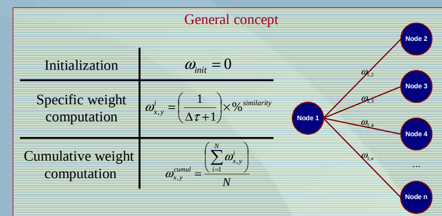


B. Event-based communication strategy

The communication strategy that has been chosen for exchanging pedestrian information between nodes exploits an event-based paradigm using weights between the different communication paths. This approach favours the communication between nodes that have observed similar events within a given time interval.

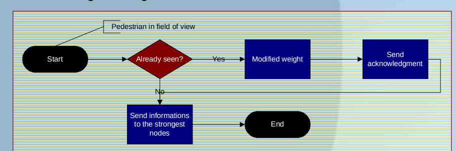
C. Weight update

Each node is connected via a weighted link to all others. The weight has a value which is included between 0 and 1. A value close to 1 means that two nodes exchange similar information frequently. When a node has to decide of a destination for a message it checks the weights and send the information to the nodes with the X strongest weights (X is a user-selected value). The equations used for updating the weights are given below. First, when a node is turned on, its weights are initialized to 0. Secondly, each time the node receives information that is very similar to what it has observed before, the node computes a specific weight for this event. Finally, the cumulative weight between two nodes is computed has the mean value of all the specific weights.



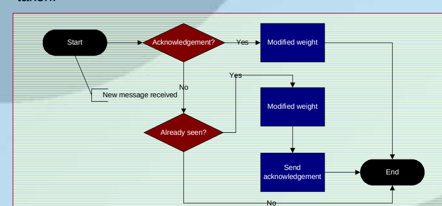
1. Message bloadcasting: dynamic weight update

The first use of the cumulative weights is when a pedestrian enters the field of view of a node. First, if the node has already observed this pedestrian itself it changes the weight associated to the distant node from whom the information has been received and sends an acknowledgement to this node. Secondly, if the node has never observed the pedestrian it sends his description to the nodes with the X strongest weights.



2. Message receiving : dynamic weight update

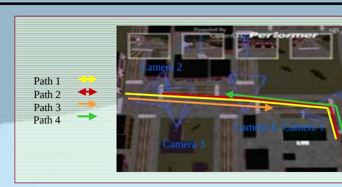
The cumulative weights are also used in receiving mode. First, if a node receives an acknowledgement message from another node, it adjusts the weight relevant to this node. Secondly, if the received information by a node is not an acknowledgement, the node checks whether the pedestrian has already been observed or not. If the pedestrian has already been observed, it changes the weight relevant to the node which has sent the information and sends an acknowledgement to this node. Otherwise, no clear decision can be made on this pedestrian and, consequently, no actions are taken.



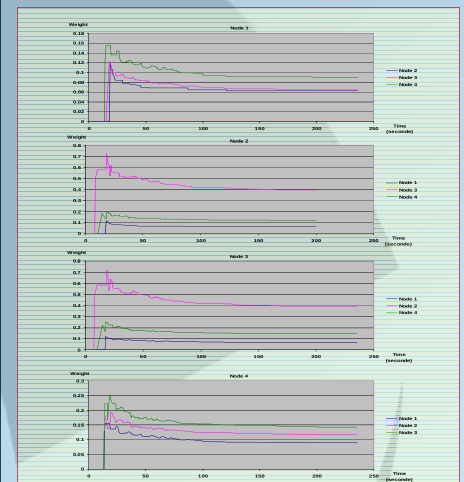
4. Results

Experimentation

Simulation results show the performance of the presented communication protocol. In the simulations, 100 pedestrians were generated and were instructed to walk in the environment shown below. The path, speed, and starting time of each pedestrian were generated randomly. The MONNET surveillance network was composed of 4 nodes, some of which shared part of their field of view. According to the communication protocol described previously, each node sent pedestrian information to the nodes with the 2 strongest weights.



4. Results (cont'd)



Based on the plots above, it is interesting to note that weights between communicating nodes converge towards a constant value over time as the network stabilizes. It is also relevant to mention that nodes which are « visually » close have stronger weights than those which are farther apart with respect to the observed areas in the environment. This demonstrates that a simple, yet efficient communication strategy based on time- adjusting weights yields interesting results when exploited in the MONNET architecture of loosely-coupled computer vision nodes.

5. Conclusion and future Work

This poster has presented a simple communication strategy for the MONNET network of loosely-coupled cameras. The strategy is based on a weighting mechanism between nodes that are observing pedestrians and which exchange information on these pedestrians as they walk in front of the fields of view of the cameras. The next steps in the project will be to study the effect of dynamic reconfiguration of the nodes on the weighting mechanism and to implement the communication protocol on the actual MONNET system.

6. References

[APIA]François Bernier, Denis Poussart, Denis Laurendeau and Martin Simoneau-Drolet, "Interaction-Centric Modelling for Interactive Virtual Worlds: the APIA Approach", in Proc. ICPR 2002, (Quebec, Canada), Aug. 11-15 2002.

[VSAM] R.T. Collins, A.J. Lipton, T. Kanade, H. Fujiyoshi, D. Duggins, Y. Tsin, D. Tolliver, N. Enomoto, O. Hasegawa, P. Burt, L. Wixson, "A system for video surveillance and monitoring", VSAM final report, 2000 Carnegie Mellon University

Acknowledgments

This research is supported by Precarn Associates and DRDC-RDDC-Valcartier.