Jean Gourd — Statement of Research

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I believe that research and teaching collectively support one another. Research strengthens teaching; teaching sustains research. As a result, a lot of what drives my research is not only based on my personal interests within the field of computer science, but is also influenced by what I teach and, perhaps more specifically, the feedback that I receive from the students that I teach. I find that my personal interests generally direct my research and that teaching tends to more precisely focus it.

My research interests primarily lie in the area of soft computing with a focus on mobile code. I am particularly interested in the application of mobile intelligent agents in a heterogeneous data gathering setting, in combination with other soft computing techniques such as fuzzy logic and expert systems which ultimately aid in facilitating the data fusion process.

Soft Computing

Soft computing represents an amalgamation of several techniques predominantly related to artificial intelligence. These techniques are used to model and analyze difficult problems which represent very complex phenomena that continue to remain intractable. Such complex systems as, for example, biological systems prove difficult to model and analyze using conventional methods. Soft computing provides tools to assist in the study of challenging problems that typically possess innate aspects of uncertainty.

There are a wide variety of techniques that belong within the soft computing milieu; fundamental areas include fuzzy logic, artificial neural networks, chaos theory, and evolutionary computation. I am particularly interested in fuzzy logic and certain characteristics of evolutionary computation which include evolutionary algorithms (e.g. genetic programming) and swarm intelligence.

Current Research

Mobile code is becoming more popular of late. For example, consider the growing use of laptops, cellular phones, bluetooth technology, and the use of the Java language to propel applications to a mobile level [3]. Clearly associated security, validation, and verification concerns must be addressed primarily due to the fact that programming is getting more complicated. Wireless outages will (and do) inevitably occur. Mobile elements are typically resource poor and unreliable, often utilizing low-bandwidth wireless links.

Typically, mobility encompasses two separate aspects [6]: In *mobile computing*, computing is done on mobile devices (e.g. browsing the WWW on a laptop via a wireless Internet connection). On the other hand, *mobile computation* embraces the idea of moving the computations themselves (e.g. employing the use of mobile intelligent agents which migrate to separate hosts in order to gather, filter, and fuse data). I am more interested in the latter, although often utilize the former in order to facilitate the process.

I am currently working on data gathering mobile intelligent agents. A major issue in the gathering of data and information lies in the heterogeneity of the data that resides on distributed relational databases, file servers, and so on. The process of gathering this data and ultimately fusing them for presentation to the end user, some expert system, or dedicated framework becomes quite a non-trivial task. In support of and answer to this issue, we have proposed a multi-agent fuzzy logic framework designed to provide a fused input to an external inclusive decision support system. This framework provides mechanisms to gather heterogeneous data–utilizing intelligent mobile agents–which are then fed to a reconfigurable fuzzy logic engine. In turn, the resulting output is presented to the user either directly via some sort of GUI or to a high-level decision support system. The fuzzy logic engine supports an interchangeable set of rules which can be utilized in support of some specific problem domain. The intelligent mobile agents are utilized to collect, sort, filter, and fuse the heterogeneous data for inclusion in the fuzzy logic engine. This project is currently being funded by the Department of Defense Space and Missile Defense Command.

Currently, there is a serious lack of standards that define the security of many mobile code aspects, including mobile intelligent agents. The presence of mobile agents on any system via a supporting agency introduces numerous security concerns. Mobile agents are not yet widely used and/or accepted; there is a severe lack of clarity with respect to the security of mobile agents which renders them ill-defined. Furthermore, no exhaustive strategy has been proposed to assist in securing computer systems that support mobile agents.

Generally speaking, security threats become increasingly significant in the presence of mobile code. Particular to mobile agents is their intrinsic vulnerability once situated on a host. Typically, the mobile agent must give access to its code, potentially its state, and at times its data. This poses a difficult problem for mobile agent designers. Perhaps, for example, the owner of a mobile agent does not wish to release its code to an agency (i.e. it is of a proprietary nature).

Often, it is desirable to model a proposed mobile agent framework prior to realizing its existence in order to prove important attributes of the system such as robustness and scalability. Modeling systems which exhibit aspects of mobility introduces a level of complexity due to the inherent dynamic topology of the environment [5]. Typically the models are complex because so many variables are involved. Often, modeling such systems is intractable and cannot be entirely solved using computers; therefore, they tend to be modeled at higher levels of abstraction [4]. In any case, the use of modeling allows us to reason about such complex systems and models formally, often in a mathematical manner [1]. Furthermore, there is often a need to formally model the movement of processes across administrative domains (which tends to introduce additional security concerns) [2].

As a result, my doctoral research addressed the modeling of security of the mobile agent paradigm by directly extending the API-Calculus [7, 8]. By integrating cryptographic primitives and appending syntactic actions and conditions, my goal was to provide a method to accurately model the intricate aspects of mobile agent security–including the security of the agency–in multi-agent systems.

I have also participated in related research primarily involved with the union of mobile agents and web services and have actively worked on the design and writing of several grant proposals in this area.

Future Directions

Initially, I wish to continue my work with mobile intelligent agents in a multi-agent system setting. Clearly, there is much more work to be done with respect to the security of agents and agencies. Furthermore, I wish to continue my current work regarding the modeling of the security of mobile systems.

I am also currently looking into establishing a confidence measure in the data a mobile intelligent agent gathers. In the case of our fuzzy logic/mobile agent framework mentioned above, we believe that incorporating some measure of confidence will lead to more accurate output for the user.

There are numerous problems and countless issues that plague the domain of multi-agent systems. Although I tend to favor mobile agents in a data gathering setting, they may certainly be used in many other areas of computer science (e.g. robotics and network management). My long term research goals currently incline towards the interesting characteristic of self-organization in multi-agent systems. Quite often, intelligent agents exhibit characteristics which may be attributed to biological systems. For example, agents often work in a cooperative environment, wherein many collaborate to solve a uniform problem. I wish to incorporate more biological aspects into my research and thus believe that utilizing numerous soft computing techniques may aid in solving some of the very difficult problems we face in this area. I am particularly interested in researching particle swarm optimization and its potential uses in the paradigm of mobile intelligent agents.

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