1. **Current Research Interests:**

   My research interests are currently in the areas of Pattern Recognition, Learning systems, Co-operative systems, and Robotics. During my Ph.D. research I covered topics related to the utilization of co-operative systems in recognition. A large part of my research was focused on the challenge of using Multiple Experts. As the possibilities of combining experts become a more important direction in intelligent systems, difficulties arise in ways of generating these various experts and how to effectively use them concurrently. More complex approaches that integrate the goal in the approach of developing the multiple-expert environment and make them more co-operative are the current research trend. These approaches present a rich platform for the design and development of various applications in the field of intelligent systems.

2. **Overview of Research Contribution:**

   Research in the area of machine intelligence has achieved significant progress in the concept of learning from sampled labeled instances. Although many efficient algorithms have been proposed, they have been limited to simple concepts or problems. Furthermore, numerous results suggest that learning more difficult concepts tends to be extremely difficult. Two research directions have evolved to address these difficulties. One is the construct multiple classifier systems (MCS), and the other is active learning. A good understanding of how to build more sophisticated MCS and exploit various possibilities of extracting information from the environment will move us closer to achieving the original intent of machine intelligence, which is to automate the knowledge acquisition process.

   Machine learning has been a challenging research area, yet a human apprentice is able to learn fairly complex concepts relatively easily by observing how competent experts make their classification. Humans also model active learning, once a learned concept falls short of success they reiterate to modify these concepts. To implement this approach for active learning, I studied means of combining the use of deduction and induction in a learning framework. This integration allowed for the system to modify and add rules to an existing knowledge base while running, overcoming deficiencies as they occur.

   In the aspects related to the other approach of MCS, a general question remains on when to trust which expert. The output of each expert depends on some input (instance) in each trail. Most classifier combining techniques don’t make use of the specific instance when determining means to combine the various experts. In my research, I have presented a new and general framework for combining multiple classifiers. The basic idea of this architecture is to compose a hierarchal set of classifiers to capture the behavior of the ensemble of classifiers, and then use the set to aggregate the classifiers' outputs. These approaches present a rich platform for the design and development of various applications in the field of intelligent systems. The architecture can be divided into two stages:

   - **Detector:** Each detector append the output of the ensemble to the input features to the ensemble classifiers and attempts to extract useful information for the aggregation procedure, rather than trying to solve the classification problem. In other words, each detector tries to understand and collect information to generate a weighting factor or confidence in each member of the ensemble for any given input vector.
Aggregation: The aggregation procedure represents the fusion layer of all the different outputs to generate a more competent output. The aggregation procedure uses the detectors' outputs to guide the means of combining the different classification results.

In most multiple classifier systems, each component is trained independently. Although each component is optimized and achieves a high accuracy, the final classification does not reflect this improvement. In my research I presented an incremental learning algorithm, Evolving (EVOL) algorithm, to rectify this issue. In this algorithm, the ensemble of classifiers, as well as the detector and aggregation networks, are allowed to focus on further training on the feature sub-space with the higher misclassification. Also, the algorithm presents a method to reduce the amount of required training by focusing on the quality of the training. An empirical study has shown the effectiveness of both the architecture and the learning algorithm over existing approaches. The architecture provides a means to limit the intervention of a user while maintaining a level of accuracy that is superior to most approaches. In addition, the architecture implemented with the EVOL algorithm determines the amount of quality training required. The time complexity of the algorithm is shown to improve on the training requirements of the architecture. Some of the techniques studied were applied to automatic cheque processing applications.

My research in Multiple Classifier Systems (MCS) has led to the publication of several Journal, Conference and book chapters. I have collaborated in various industrial research projects that have impacted my research. I have also aided in writing a few research grant proposals that have proven to be very successful as well as acting as a reviewer for a variety of journals and conferences in the area of my specialization.

3. **Future Research:**

I am interested in conducting research that focuses on the use of multiple expert systems, distributed systems in the fields of Robotics, and intelligent Agents and decision support systems and smart systems design.

- **Intelligent Agents:**

  Agents that adapt themselves to their environment have been an interesting research modeled after the way which organisms organize themselves. Although they are still primitive, artificial-life agents are truly autonomous: in effect, they program themselves. Their software is designed to change its behavior based on experience and on interactions with other agents. Agents can also learn from agents that perform the same task. An E-mail agent faced with an unknown message might query its counterparts to find out. Such collaboration can make it possible for collections of agents to act in sophisticated, apparently intelligent ways even though any single agent is quite simple. It would be of my research interest to explore possibilities of cooperative learning in the domain of intelligent agents.

- **Data Mining and Data Fusion:**

  We live in the age of information, and as organizations everywhere attempt to digitize all of their records people are often left drowning in data from multiple sources. One may claim that this exponential growth in the amount of data provides great opportunities for data mining. Reality can be different though. In many real world applications, the number of sources over which this information is fragmented grows at an even faster rate, resulting in barriers to widespread application of data mining and missed business opportunities. The problem is particularly
noticeable for systems engineers who provide assistance for the analysis and design of large-scale systems that meet the often conflicting objectives of organizations. With these increasing levels of data availability from multiple sources, most engineers look for automated support through data fusion and data mining techniques to combine disparate sources of data into a more coherent, merged information assessment. In this role, data fusion is an information processing task that uses both knowledge of data sources with advanced methods for data analysis and synthesis. Data fusion combines and interprets information from multiple sources, while at the same time organizing and cleaning the data. I am interested in exploring data fusion and data mining techniques in document processing. Applications include, browsing and navigation; user-centered information retrieval and dissemination; user modeling; information source discovery and information fusion.

Robotic Systems:

Distributed and cooperative robotics has been the focus of attention of many groups in recent years. The idea of using a team of robots (in general mobile robots), instead of a single one, to execute a task came from the necessity of accomplishing a task that is too difficult or too complex for a single robot. In other situations to use a group of simple robots can be more efficient, easier, less expensive, more flexible and more fault-tolerant than having a single powerful, highly specialized robot for each task.

Following this trend of flexibility and versatility by distribution, a new research field called "Distributed Sensing" has arisen. It is based on two key ideas: 1) sensor fusion can improve the robot knowledge about the world and 2) multiple mobile robots endow more flexibility in the execution of tasks. In general, with Distributed Sensing or "Distributed Sensor Fusion" information is extracted from data of several sensors of several sensing modalities that are scattered in the working area. This definition can be further expanded to include active sensors that can move and interact, and, thus, modify their environment.

I am interested in pursuing research in the area of cooperative robotics. Specifically, while not limited to, the area of distributed sensing and decision making.

4. Publications (Summary: 2 Book chapter, 2 Thesis, 2 journals, 10 conferences, 1 non-referred article):

**Book Chapters:**

**Thesis:**

**Refereed Journal Papers:**

**Refereed Conference Papers:**


[C6] N. Wanas, and M. Kamel (2001), Feature based decision fusion, International Conference on Advances in Pattern Recognition (ICAPR ’01), Rio de Janeiro, Brazil.


Technical Reports:

Non-Refereed Articles: