

# Understanding Intent Using a Novel Hidden Markov Model Representation

**PI: Monica N. Nicolescu (UNR)**

**Co-PI: Mircea Nicolescu (UNR)**

## Executive Summary

**The problem:** Understanding intent is a critical aspect of communication among people and for many biological systems. This is particularly important in situations that involve collaboration among multiple agents or assessment of potential threats. During the recent years, there has been an increased interest in using robotic technologies for security and defense applications, in order to reduce the danger for the people involved. However, the current systems deployed by the US Army (e.g., Hermes)<sup>1</sup> and the US Air Force (e.g., MDARS)<sup>2</sup> rely heavily on input from a human operator who assesses the situation and takes a decision. Thus, in the context of these applications, being able to automatically detect any threatening situations is of critical importance. This reduces to the problem of understanding the intent of the other agents in the environment, from their current actions, *before* any attack strategies are finalized. Toward this end, the main research problems we will address in this project are to: 1) develop a tool for modeling the behavior of relevant agents (people, robots, boats), which will incorporate the predictive capabilities necessary to infer those agents' intentions, and 2) develop novel vision-based techniques for target detection and tracking, which will provide essential sensory information to the modeling engine.

**Proposed solution:** To address the above problem, this project will develop methodologies for understanding intent and apply them to tasks relevant to the military. The proposed approach relies on a novel formulation of Hidden Markov Models (HMMs), which allows a robot to understand the intent of others by virtually assuming their place and detecting their potential intentions based on the current situation. In contrast with the standard use of HMMs, which solely model transitions between discrete states, in this project the HMMs will also model the *rate* and *direction of change* for a set of relevant parameters. This approach will allow the system to recognize the intent of observed actions *before* the action has been completed, thus enabling the system to take preemptive actions for defense. The system's capability to observe and analyze the current scene will employ novel vision-based techniques for target detection and tracking, using a multivariate non-parametric kernel density estimation methodology that we will develop as a part of this project.

An important advantage of the proposed work is that the obtained results will generalize across different application domains, from land to naval or air missions.

**Objectives:** The primary objective of this work is to design an effective and robust system for automatic behavior modeling that will provide effective detection of threatening situations in the context of military and security applications. Specifically, we will work toward the following objectives:

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<sup>1</sup> URL: <http://www.armytimes.com/story.php?f=1-292925-1034207.php>

<sup>2</sup> URL: <http://www.nosc.mil/robots/land/mdars/mdars.html>

Investigate and design an integrated system for automatic behavior modeling that allows for detecting intent from observed actions.

Develop novel vision-based techniques for target detection and tracking, which will provide essential sensory information to the modeling engine

Integrate the above capabilities into a prototype system that will be tested under reconnaissance-type mission scenarios, such as monitoring a security-sensitive area or guarding a high-value target.