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Opportunity Title: Intelligent Autonomous Systems for National Security Applications
Opportunity Reference Code: IC-17-22

Organization Office of the Director of National Intelligence (ODNI)

Reference Code IC-17-22

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Complete your application – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant.

Application Deadline 3/31/2017 11:59:00 PM Eastern Time Zone

Description **Research Topic Description, including Problem Statemen**t:

Robotic systems, and more specifically, airborne vehicles (e.g., quadcopters/UAV/drones) have captured both the public’s and military’s imagination with an ever increasing display of aerobatic capabilities, and potential applications. Today, drones are used in a multitude of applications that range from previewing real estate to the delivery of pizzas and merchandise to the home. The military now employs low cost drones, or small UAV’s for aerial surveillance in hostile or combat areas.

But a major limitation of most drones/small UAV’s, is that they navigate from point A to point B, by either pre-programmed GPS coordinates, and/or, by human/operator control. Unfortunately, that limits their applicability to situations where GPS is not obstructed (denied), and/ or field situations where constant human interaction is maintained. Navigation is not possible without the availability of one, or both of the aforementioned aides.

In order to enable robotic systems, the ability to navigate when human or GPS guidance is not available, robotic autonomy is rapidly becoming an important area of research in the development of “smart” systems (e.g., “smart cars”). Autonomy, in this sense, is the development of probabilistic approaches, coupled with decision making algorithms, which collectively, (a) enable the robotic system to become “self-aware” of its surroundings, and (b) make appropriate decisions (much like a human would) in determining a course of action (eg, direction, grab or releasing a payload, power down/up, etc).

The military, and in particularly DARPA, has recently begun to address the development of small, fast and autonomous UAV’s. DARPA claims that, if successful, these algorithms could enhance unmanned system capabilities by reducing the amount of processing power, communications, and human intervention needed for navigating cluttered areas and responding to emergency situations. Furthermore, and perhaps more significantly, it was pointed out by Stefanie Tompkins, the Director of DARPA’s Defense Sciences Office – “The benefits of such algorithms go far beyond UAVs.

Ground, marine and underwater systems would also stand to benefit, as would operations in environments where GPS data is unreliable or unavailable".

It should be pointed out that the development of autonomous robotic systems is a large, and diverse area of research that encompass many different technical approaches. The intent of our project is not to duplicate the DARPA effort, but to focus on a specific task, which has quite different goals/objectives from DARPA. Below are links to two articles which describe the DARPA work:

https://herox.com/news/156-darpas-latest-goal-create-autonomous-bird-of-prey

https://www.engadget.com/2014/12/23/darpa-fast-lightweight-autonomy-uav/

Example Approaches:

Examples of technical approaches/components could include the following elements:

1) Autonomous operation using a behavior based paradigm
A behavior can be modeled as a dynamical system with one or more inputs and one or more outputs. It may have an internal state. Indeed, finite state automata are used to model a large class of behaviors. Control theory, especially the control of "hybrid" systems (mixed discrete and continuous variables and controls) is relevant as a modeling and design framework for robots with multiple behaviors. As such, the use of a behavior-based framework, to define control strategies for the aerial robot, is desirable. Examples of some behaviors are: (a) Exploration/directional behaviors (move in a general direction) heading based, wandering; (b) Goal - oriented appetitive behaviors (move towards an attractor) discrete object attractor, area attractor; (c) Aversive/protective behaviors (prevent collision) avoid stationary objects, elude moving objects (escape); (d) Path following behaviors (move on a designated path) road following, hallway navigation, stripe following; (e) Perceptual behaviors visual search, ocular reflexes

2) Bayesian programming to deal with uncertainty and to support robot "learning.
At a higher level a different approach is needed for management of the collection of behaviors required to resolve the complex problems encountered by robots in the "real" world. We believe that the language of discrete event systems theory, combined with elements of Bayesian programming represents a useful starting point.

3) Probabilistic Robotics
A robot performing a complex task in a complex environment will almost surely encounter uncertainty. Where exactly am I? What does that sensor

measurement mean? How effective was that control action? And so on. These basic questions should be addressed in a suitable framework.

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Business** (11)
  - **Chemistry and Materials Sciences** (12)
  - **Communications and Graphics Design** (6)
  - **Computer, Information, and Data Sciences** (16)
  - **Earth and Geosciences** (21)
  - **Engineering** (27)
  - **Environmental and Marine Sciences** (14)
  - **Life Health and Medical Sciences** (45)
  - **Mathematics and Statistics** (10)
  - **Other Non-Science & Engineering** (13)
  - **Physics** (16)
  - **Science & Engineering-related** (1)
  - **Social and Behavioral Sciences** (28)