Artificial Intelligence Exploration (AIE) Opportunity
DARPA-PA-18-02-04
Intelligent Neural Interfaces (INI)

I. Opportunity Description

The Defense Advanced Research Projects Agency (DARPA) is issuing an Artificial Intelligence Exploration (AIE) Opportunity inviting submissions of innovative basic or applied research concepts in the technical domain of neurotechnology.

This AIE Opportunity is issued under the Program Announcement for AIE, DARPA-PA-18-02. All proposals in response to the technical areas described herein will be submitted to DARPA-PA-18-02 and if selected, will result in an award of an Other Transaction (OT) for prototype project. The total award value for the combined Phase 1 base and Phase 2 option is limited to $1,000,000. This total award value includes Government funding and performer cost share, if required.

A. Introduction

Recent progress in central and peripheral neural interface technology has resulted in impressive capability demonstrations. These include the use of neural signals to control the reanimation of paralyzed muscles or to control high-dimensional prosthetic limbs, external robots, and even flight simulators. In many of these examples, sensory feedback from the external application is also delivered to the brain via neural stimulation. Successful systems to date have utilized artificial intelligence methods such as neural networks, evolutionary algorithms, and state space machine learning algorithms. While these methods have shown promise in the laboratory, a number of challenges still exist.

B. Objective/Scope

This AIE Opportunity for the Intelligent Neural Interfaces (INI) program is soliciting proposals to establish the proof of concept prototype for third-wave artificial intelligence methods that could improve and expand the application space of next-generation neurotechnology. Teams will address two major challenges specific to central and/or peripheral neural interfaces. These challenges include: (1) decision making for sustainment and maintenance of neural interfaces to promote robustness and reliability, and (2) modeling and maximizing the information content of biological neural circuits to increase the bandwidth and computational abilities of the neural interface.

C. Structure

Proposals submitted to DARPA-PA-18-02 in response to the technical areas of this AIE Opportunity must be UNCLASSIFIED and must address two independent and sequential project phases (a Phase 1 Feasibility Study (base) and a Phase 2 Proof of Concept (option)). The periods of performance for these phases are 6 months for the Phase 1 base effort and 12 months for the Phase 2 option effort. Combined Phase 1 base and Phase 2 option efforts for this AIE Opportunity should not exceed 18 months. The Phase 1 (base) award value should not exceed $400,000. The Phase 2 (option) award value should not exceed $600,000. The total award value

for the combined Phase 1 and Phase 2 is limited to $1,000,000. This total award value includes government funding and performer cost share, if required. Proposers may address multiple technical areas (TAs). Please note that proposers shall address only one TA per proposal.

Phases 1 and 2 must not include active human or animal research. Previously collected animal datasets may be used for data analysis.

The Government reserves the right to award all, some, one, or none of the options on the agreements(s) of the Phase 1 performers based on available funding, Phase 1 technical performance, and an assessment of the feasibility of the approach.

D. Technical Area Descriptions

TA1: Neural Machine Maintenance
Neural decoders often need to be recalibrated. This is typically due to non-stationary neural processes as well as unstable neural recordings. This effort will aim to design a prototype of an artificially intelligent system for stabilizing decoder performance over long periods of time. Teams may use previously collected longitudinal data from animals or may appropriately simulate expected system disruptions. Examples of stabilization methods could include but should not be limited to:

- automated decoder recalibration when neurons are lost or when new neurons are added to a recorded population
- impedance monitoring accompanied by automated electrode stimulation protocols for impedance reduction

TA2: Maximize Information Content
The peripheral nerve carries information for motor control and sensory feedback. Artificial stimulation of the nerve creates additional sensory percepts. This effort will design prototype artificial intelligent interfaces to maximize information content carried on the major mammalian peripheral nerves in the upper extremity for subsequent cortical processing. Teams will determine how to maximize information content in intact neural systems by interfacing to nerve pathways and multiplexing artificial signals with existing biological signals that will be processed upstream by the cortex.

E. Schedule/Milestones

Proposers must address the following research project objectives, metrics, and deliverables, along with fixed payable milestones in their proposals. The task structure must be consistent across the proposed schedule, Task Description Document (TDD), and the Vol. 2 - Price Volume. Proposers must complete the "Schedule of Milestones and Payments" Excel Attachment provided with this AIE opportunity as part of submitting a complete proposal and fulfilling the requirements under Vol. 2 - Price Volume. Performers can supplement the required milestones with additional milestones, if needed, and should propose estimated funding for each. If selected for award negotiation, the fixed payable milestones will be directly incorporated into Attachment 2 of the OT agreement ("Schedule of Milestones and Payments"). Proposers are encouraged to use the TDD template provided with this AIE opportunity, which will be Attachment 1 of the OT agreement.

For planning and budgetary purposes, proposers should assume a program start date of May 1, 2019. Schedules will be synchronized across performers, as required, and monitored/revised as necessary throughout the program. Proposals must include delivery schedules for Phase 1 and Phase 2 that include timelines for preliminary (to facilitate inspection by the Program Manager) and final (to facilitate evaluation) release of deliverables.

Proposals for the INI program shall include, at a minimum, the fixed milestones listed below, but proposers should provide additional detail, specific to their proposed project, as necessary.

TA1: Neural Machine Maintenance

Phase 1:

- Month 2: Report describing known empirical disruptions to neural interfaces over time
- Month 3: Report describing the team's simulated disruptions to the system over time (e.g., rate of neural dropout, gain or impedance changes, etc.). Include preliminary functional block diagram of the new algorithm(s), architecture review and discussion of the advanced AI techniques to be employed
- Month 5: Report describing how these algorithms could be implemented using a neural interface system and tested in online experiments
- Month 6: Final report with a preliminary quantification of algorithm performance using previously collected longitudinal data or simulated disruptions. Include a detailed plan of Phase 2 activities

Phase 2:

- Month 9: Report comparing ability to decode neural signals post-disruption to pre-disruption (baseline) decoder performance
- Months 12: Interim report quantifying algorithm performance using offline longitudinal data or simulated disruptions on a limited dataset
- Month 15: Interim report quantifying algorithm performance using offline longitudinal data or simulated disruptions on a limited dataset
- Month 18: Delivery of final prototype algorithms, demo and report describing data, algorithm architecture, quantification of accuracy, comparison to state of the art (SOA) as well all other pertinent code

TA2: Maximize Information Content

Phase 1:

- Month 3: Report assessing theoretical information bandwidth of the major mammalian peripheral nerves in the upper extremity. Discuss the upper limit of possible information transfer as well as typical information transfer during activities of daily living.
- Month 5: Preliminary report describing the ability of various neural interfaces and stimulation methods to leverage available bandwidth. Describe how this ability could be tested in online experiments and discuss advanced AI techniques to be employed
- Month 6: Final report overviewing Phase I activities. Include a detailed plan of Phase 2 activities

Phase 2:

- Month 12: Report describing the exploration of optimal neural interfaces and stimulation methods for maximizing use of available bandwidth
- Month 15: Define ideal stimulation methodology for bandwidth utilization and discuss how the stimulation method would change across multiple use cases
- Month 18: Final prototype software, models, simulation, and report describing the final methodology, characterization of outcomes as well as pertinent code

All proposals must include the following meetings and travel in the proposed schedule and costs:

- To foster collaboration between teams and disseminate program developments, a two-day Principal Investigator (PI) meeting will be held approximately every six months. For budgeting purposes, plan for three two-day meetings over the course of 18 months: two meetings in the Washington, D.C. area (once during Phase 1 and once during Phase 2) and one meeting in the San Francisco, CA area (once during Phase 2).
- Regular teleconference meetings will be scheduled with the Government team for progress reporting as well as problem identification and mitigation. Proposers should also anticipate at least one site visit per phase by the DARPA Program Manager during which they will have the opportunity to demonstrate progress towards agreed-upon milestones.

F. Deliverables

In addition to the deliverables required for the Phase 1 and 2 milestones, performers will be expected to provide at a minimum the following deliverables:

- Negotiated deliverables specific to the objectives of the individual efforts. These may include registered reports, experimental protocols, publications, intermediate and final versions of software libraries, code, and APIs, including documentation and user manuals, and/or a comprehensive assemblage of design documents, models, modeling data and results, and model validation data.
- Unless otherwise specified, all deliverables are expected to be released under open-source licenses using standard best practices for versioning and usability.

II. Award Information

Selected proposals that are successfully negotiated will result in the award of an OT for prototype project. See Section 3 of DARPA-PA-18-02 for information on awards that may result from proposals submitted in response to this notice.

Proposers must review the model OT for prototype agreement provided as an attachment to DARPA-PA-18-02 prior to submitting a proposal. DARPA has provided the model OT in order to expedite the negotiation and award process and ensure DARPA achieves the goal of AIE, which is to enable DARPA to initiate a new investment in less than 90 days from the date that this AIE opportunity is posted to www.FBO.gov. The model OT is representative of the terms and conditions that DARPA intends to award for all AIE awards. The task description document, schedule of milestones and payments, and data rights assertions requested under Volumes 1, 2, and 3 will be included as attachments to the OT agreement upon negotiation and award.

Proposers may suggest edits to the model OT for consideration by DARPA and provide a copy of the model OT with track changes as part of their proposal package. Suggested edits may not

be accepted by DARPA. The Government reserves the right to remove a proposal from award consideration should the parties fail to reach agreement on OT award terms and conditions. If edits to the model OT are not provided as part of the proposal package, DARPA assumes that the proposer has reviewed and accepted the award terms and conditions to which they may have to adhere and the sample OT agreement provided as an attachment, indicating an agreement (in principle) with the listed terms and conditions applicable to the specific award instrument.

In order to ensure that DARPA achieves the AIE goal of award within 90 days from the posting date (January 31, 2019) of this announcement, DARPA reserves the right to cease negotiations when an award is not executed by both parties (DARPA and the selected organization) on or before May 1, 2019.

III. Eligibility

See Section 4 of DARPA-PA-18-02 for information on who may be eligible to respond to this notice.

IV. AIE Opportunity Responses

Responses to this AIE Opportunity must be submitted as full proposals to DARPA-PA-18-02 as described therein. All proposals must be unclassified.

A. Proposal Content and Format

All proposals submitted in response to this notice must comply with the content and format instructions in Section 5 of DARPA-PA-18-02. All proposals must use the templates provided as Attachments to the program announcement and the "Schedule of Milestones and Payments" Excel Attachment provided with this AIE Opportunity and follow the instructions therein.

Information submitted but not explicitly requested in DARPA-PA-18-02, its Attachments, or this notice may not be evaluated.

B. Proposal Submission Instructions

See Section 5 of DARPA-PA-18-02 for proposal submission instructions.

C. Proposal Due Date and Time

Proposals in response to this notice are due no later than 4:00 PM on March 4, 2019. Full proposal packages as described in Section 5 of DARPA-PA-18-02 must be submitted per the instructions outlined therein *and received by DARPA* no later than the above time and date. Proposals received after this time and date may not be reviewed.

Proposers are warned that the proposal deadline outlined herein is in Eastern Time and will be strictly enforced. When planning a response to this notice, proposers should take into account that some parts of the submission process may take from one business day to one month to

complete.

V. Proposal Evaluation and Selection

Proposals will be evaluated and selected in accordance with Section 6 of DARPA-PA-18-02. Proposers will be notified of the results of this process as described in Section 7.1 of DARPA-PA-18-02.

VI. Administrative and National Policy Requirements

Section 7.2 of DARPA-PA-18-02 provides information on Administrative and National Policy Requirements that may be applicable for proposal submission as well as performance under an award.

VII. Point of Contact Information

Al Emondi, Program Manager, DARPA/BTO, INI@darpa.mil

VIII. Frequently Asked Questions (FAQs)

All technical, contractual, and administrative questions regarding this notice must be emailed to INI@darpa.mil. Emails sent directly to the Program Manager or any other address may result in delayed or no response.

All questions must be in English and must include name, email address, and the telephone number of a point of contact. DARPA will attempt to answer questions publically in a timely manner; however, questions submitted within 7 days of the proposal due date listed herein may not be answered.

DARPA will post an FAQ list under the AIE Opportunity on the DARPA/BTO Opportunities page at https://www.darpa.mil/work-with-us/opportunities?oFilter=1. The list will be updated on an ongoing basis until one week prior to the proposal due date. In addition to the FAQ specific to this notice, proposers should also review the Program Announcement for AIE General FAQ list on the DARPA/DSO Opportunities page under the Program Announcement for AIE (DARPA-PA-18-02).