Organization: Texas A&M Engineering Experiment Station

Proposal Detail:

Proposal Information

Proposal Number:

1617826

Proposal Title:

RI: Small: Autonomous Construction and Use of Simple to Complex Tools

Received by NSF:

11/18/15

Principal Investigator:

Yoonsuck Choe

This Proposal has been Electronically Signed by the Authorized Organizational Representative (AOR).

NSF Program Information

NSF Division:

Div Of Information & Intelligent Systems

NSF Program:

ROBUST INTELLIGENCE

Program Officer:

Hector Munoz-Avila

PO Telephone:

(703) 292-7129

PO Email:

hmunoz@nsf.gov

Review Information:

External Peer Review began on 02/29/16

Proposal Status

Status As of Today Dated: 05/16/16

This proposal has been declined by NSF.

Our records indicate that the following Annual Project Report(s) are due or overdue for the Award(s) listed below. Please submit the report(s) as soon as possible using the Project Reports System within FastLane.The report(s) will be considered overdue if not submitted by the Report Overdue Date mentioned for each report. Having an Overdue project report will affect/delay NSF actions on any other award related to the PI/Co-PI:

Award 1256086: Annual Report overdue for period ending 04/30/2016 for Yoonsuck Choe

Reviews

All of the reviews of your proposal that have been released to you by your NSF program officer can be viewed below. Please note that the Sponsored Project Office (or equivalent) at your organization is NOT given the capability to view your reviews.

Document:

Release Date:

Panel Summary #1

May 10 2016 11:22AM

Review #1

May 10 2016 11:13AM

Review #2

May 10 2016 11:13AM

Review #3

May 10 2016 11:13AM

Review #4

May 10 2016 11:13AM

Review #5

May 10 2016 11:13AM

Context Statement

Context Statement

In November 2015, the IIS Division received 705 proposals totaling 608 projects for review in the fiscal year 2016 Small budget class size for the "Information and Intelligent Systems(IIS):Core Programs," solicitation (NSF 15-574) Additional information about the solicitation can be found at http://www.nsf.gov/pubs/2015/nsf15574/nsf15574.htm

Proposals submitted to the IIS Division in response to the "Information and Intelligent Systems (IIS): Core Programs," solicitation are reviewed in panels to permit comparison of related proposals. In some cases, the Division also seeks the advice of several independent ad hoc reviewers for proposals to complement the

evaluations provided by the panel review. In rare cases, proposals will only receive ad hoc review, for instance, if the topic doesn't fit within a scheduled panel.

Merit review is a critical component of the National Science Foundation's decision-making process for funding research and education projects. Through the use of rigorous, competitive merit review, NSF maintains high standards of excellence and accountability. It enables investments in projects that couple the best ideas from the most capable researchers and educators, with the advancement of discovery and learning and the enrichment of the science and engineering resources. The merit review criteria are:

1. What is the intellectual merit of the proposed activity?
2. What are the broader impacts of the proposed activity?

Additional information on NSF's merit review criteria can be found at http://www.nsf.gov/bfa/dias/policy/meritreview/; http://www.nsf.gov/pubs/policydocs/pappguide/nsf15001/nsf15_1.pdf (Grant Proposal Guide - Chapter III)

Please refer to the Reviews section above for copies of the reviews and a panel summary, if applicable (on Fastlane at: https://www.fastlane.nsf.gov/jsp/homepage/proposals.jsp). (A panel summary will not be provided for triaged proposals, or for proposals that received only ad hoc review.) In reading them, please keep in mind that reviewers are addressing their comments primarily to the NSF, not necessarily to you. Remarks are sometimes made without giving detailed references or providing specific suggestions for improvement, although reviewers are encouraged to provide such helpful information.

Decisions about particular proposals are often very difficult and factors other than reviewer comments and ratings enter into the decision making process. Maintaining appropriate balance among subfields, the availability of other funds, and the total amount of funds available to the program for new and renewal proposals, and general Foundation policies are also important decision factors.

We encourage revised and resubmitted proposals that substantially address reviewer comments. Investigators are welcome to seek the advice of the Program Director before resubmissions are prepared. In addition, investigators should be aware that the Foundation will treat the revised proposal as a new proposal that will be subject to the standard review procedures. Information about reconsideration of declined proposals is found in NSF's Grant Proposal Guide (Chapter IV), which should be available at your institution, usually at the office that submitted your proposal or on the Web at: http://www.nsf.gov/pubs/policydocs/pappguide/nsf15001/nsf15_1.pdf

Please note that current IIS program descriptions, proposal submission deadlines, and other information items can be found on the WWW at http://www.nsf.gov/div/index.jsp?org=IIS. We also encourage examination of the NSF information at www.nsf.gov for announcements of new NSF-wide funding opportunities and other items of interest to the research community.

Back to Status Search Results

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Organization: Texas A&M Engineering Experiment Station

Panel Summary #1

Proposal Number: 1617826

Panel Summary:
Panel Summary

A brief statement of what the proposal is about:

The proposal lays out a plan to develop sensorimotor controllers that can be used by autonomous agents to construct and use simple and compound tools.

Intellectual merit, including extent to which the proposed activity explores creative, original, or potentially transformative concepts

- Strengths:
The proposal addresses an interesting problem domain which can provide valuable insight into intelligent behavior.
The proposed analysis of the learnt controller to understand behavioral dynamics is interesting and can be instructive.

- Weaknesses:
Simplification of the task, both from the sensing perspective, e.g., tool detection was not discussed and only 2D images were used, and the effectors available, e.g., components lock in place, may not allow for generalization of the learned

controllers to more sophisticated tool construction challenges.

The ability of the proposed method to learn more complex tools is not addressed in a convincing way.

Broader impacts, including enhancing diversity and integrating research and education

- Strengths:
The PI has demonstrated impressive outreach and educational activities from past NSF fundings. Activities planned for the current proposal, including tool construction and use challenge competitions at major conferences and showcasing results with museum exhibits, continue that commendable trend.

- Weaknesses:
Nothing of note.

Other requirements

Soundness of data management plan:

The data management plan is adequate.

Adequacy of postdoctoral mentoring plan (if applicable): N/A

Adequacy of collaboration plan (if applicable): N/A

Results from prior NSF support (if applicable):

Research, outreach, and educational outcomes from previous NSF funding of proposal #0905041 are noteworthy.

Additional suggestions:

The proposal should compare the proposed research with existing work on tool creation and use, e.g., by Sammut and collaborators.

Justification of the recommendation, including key strengths and critical weaknesses:

The panel discussed the proposal at length and panelists had mixed response to different aspects of the proposal. The problem domain of tool construction and use was deemed to be interesting and worthy of further exploration to shed more light on our understanding of intelligent behavior. However, the panel felt that issues of simplified sensing and acting modalities limited both the applicability and the generalizability of the proposed research

Panel recommendation (check one):

__ Highly Competitive
_X__ Competitive
__ Low Competitive
__ Not Competitive
__ Not Discussed in Panel

The summary was read by the panel, and the panel concurred that the summary accurately reflects the panel discussion.

Panel Recommendation: Competitive

National Science Foundation
4201 Wilson Boulevard, Arlington, Virginia 22230, USA
Tel: 703-292-5111, FIRS: 800-877-8339 | TDD: 703-292-5090

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Organization: Texas A&M Engineering Experiment Station

Review #1

Proposal Number:

1617826

NSF Program:

ROBUST INTELLIGENCE

Principal Investigator:

Choe, Yoonsuck

Proposal Title:

RI: Small: Autonomous Construction and Use of Simple to Complex Tools

Rating:

Good

REVIEW:

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

Strengths:
+ The considered problems are interesting and important.
+ The research tasks are well-planed and the proposal is based on the PI's preliminary results,

Weaknesses:
- The environment for the sensorimotor controllers is restricted to 2D plane, which simplifies the real-world scenarios.
- The proposal falls short in identifying the novelty of the proposed methods, which are mainly based on the existing NEAT algorithm.
- The discussion on how the set of sensors detects the tool or tool part is missing.
- The evaluation plan seems weak. For real-world physics including friction and collision, the PI only mentioned the use of Box2D, an open source 2D physics simulator. A more concrete evaluation plan to test the effectiveness and efficiency of the designed methods is expected.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The education and dissemination plans are standard, including the design of web portal, competition, and open source release.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

Data management plan is reasonable.

Summary Statement

The goal of this proposal is to develop algorithms for autonomous tool use and

construction for sensorimotor agents. The proposal is well-planned with a step-by-step approach, from the use of simple tools, to constructing composite tools for reaching, to constructing composite tools for dragging. However, the proposal lacks sufficient novelty and the evaluation plan seems weak.

Organization: Texas A&M Engineering Experiment Station

Review #2

Proposal Number:

1617826

NSF Program:

ROBUST INTELLIGENCE

Principal Investigator:

Choe, Yoonsuck

Proposal Title:

RI: Small: Autonomous Construction and Use of Simple to Complex Tools

Rating:

Good

REVIEW:

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The project aims at designing an environment where sensorimotor controllers can be evolved to construct and use tools of increasing complexity based on minimal knowledge about the task. This will be done via a combination of neural networks, genetic optimization, and unsupervised learning.
The tools will be tested in a real-world physics simulation.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

An open simulation environment will be developed for tool construction. It will be used for k-12 outreach. Students will be trained modeling sensorimotor learning. The work will impact robotics, cognitive science, and other sciences. A web portal will be constructed for the general public to experiment and analyze. There is no specific effort to recruit underrepresented students and to do outreach.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

The proposed work will build on neural networks that have a topology that evolves to an arbitrary connection topology using the NEATsystem. The input values to the neural network come from values of the joint angles, which have been selected by the designer. The fitness criteria are also provided by the designer.
The objective is to test if NEAT can learn how to use the tool in different situations.
For composite tools, different approaches will be tried because there is a large number of ways in which 2 tools can be composed into a more complex tool. The issue at stake is whether NEAT will be able to do it or it would need to be extended. One idea is to use an auxiliary fitness function which co-evolve with the controllers.
Next the location of tools in the environment and their affordances have also to be learned. This will be done in real-world physics simulation. Finally the controllers produces in the process will be analyzed by collecting behavioral data, clustering them, and extracting the time-series data for the actions identified in the behavioral analysis. The objective is to understand the internal dynamics in

the controllers.
The specific tools to be developed are for reaching (simple and composite with different shapes) and for dragging.
The PI has a strong track record, even though has no previous NSF support relevant to this project.
The proposal has the potentially to be transformative, but there is a high risk it will not succeed and will not be able to achieve the goal to evolve tools for general use. There is a fine line between showing what the network learns and what is provided as input.

Figures hard to read (7a the text is unreadable).

Summary Statement

The proposal will evolve sensorymotor controllers to learn how to build relatively simple tools for reaching and dragging objects. The objective is to provide the machinery that will allow to construct different types of tools from minimal knowledge.

Organization: Texas A&M Engineering Experiment Station

Review #3

Proposal Number:

1617826

NSF Program:

ROBUST INTELLIGENCE

Principal Investigator:

Choe, Yoonsuck

Proposal Title:

RI: Small: Autonomous Construction and Use of Simple to Complex Tools

Rating:

Multiple Rating: (Very Good/Good)

REVIEW:

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

The PI argues that constructions and use of complex tools is a unique skill attribute to higher intelligence, and in particular, to humans. The proposal then lays out a well-thought-out series of challenges for simple to complex tool construction and use using sensorimotor capabilities and without explicit high-level guidance. Proposed research will build on prior work on unsupervised learning and evolutionary neural networks, and hierarchical reinforcement learning.

Whereas there are significant research challenges and plausible approaches discussed, it is less clear how such learned knowledge will engender higher intelligence or even more general reusable knowledge. For example, how will learned knowledge be leveraged or transferred while working on similar tasks?

Results from prior related NSF support, though smaller in scope, shows effective use of the funding in terms of publication, training and outreach activities.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

Demonstration of higher cognitive functions such as simple and complex tool construction and use will necessitate development of more coordinated learning and sensorimotor capabilities and shed additional light on the interrelationships

between higher cognitive functions and tool construction and use.

The simulation environment to be developed as part of this project will be a useful tool for hosting robotics competitions and also for public outreach and K-12 involvement.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

Summary Statement

The ability to reproduce the capability of simple and complex tool creation and use based only on sensorimotor capabilities will require significant advancement in unsupervised and reinforcement learning, among other areas, and is likely to spawn various interesting applications.

Organization: Texas A&M Engineering Experiment Station

Review #4

Proposal Number:

1617826

NSF Program:

ROBUST INTELLIGENCE

Principal Investigator:

Choe, Yoonsuck

Proposal Title:

RI: Small: Autonomous Construction and Use of Simple to Complex Tools

Rating:

Good

REVIEW:

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual merit.

Note that at the request of the program director this review focuses on neural networks, genetic optimization and the soundness/novelty of this research.

The technical approach proposed for this project is generally sound and appropriate. NEAT is an appropriate algorithm for the proposed research and is very likely to result in successful results if the task is indeed possible û the determination of which is the goal of the research. NEAT has the significant advantage of being able to test a wide range of NN topologies, including very non-standard topologies, which may be crucial to obtaining positive results. The proposal could be slightly strengthened by also trying hyper-NEAT, which over the past several years has received significant attention as a possibly better algorithm. However, the two algorithms are similar enough that it should be simple to test both using the same basic software.
Box2D, the proposed simulation software, is widely used and well regarded. Although it is only a 2D simulator this is probably an advantage for this research as it reduces noise due to inaccuracies in the physics simulator and because it will be much faster than a 3D simulator while still addressing the research's key questions.
My concern with the research is in the general goals. The building and use of complex (or at least compound) tools seems to be important because of what it implies about general cognitive capabilities û e.g. the ability to plan ahead ("I'm going to create a termite catching stick now, that I won't use for several hours")

to generalize ("my fingers aren't long enough, but a stick is like a finger so maybe I can use a stick") to model ("this combination of elements should meet my goals"), etc. That a neural network can be evolved to make tools does not imply that it is doing any of these things. For example, in the simplest task the network has to learn to first move to where the tool is (grasping it automatically) and then move the tool to the given location. This is simply two consecutive tasks: move to point A and then to point B û succeeding at it doesn't imply the types of cognition that we believe that animal tool users go through. Similar concerns can be raised for the other, increasingly complex, tasks. Of course, in AI research the question of whether successful learning of a task (like tool building and use) relates to how a person or animal thinks about a task. But in this case I find the connection particularly tenuous. I would not be at all surprised that a NN could be evolved to solve these tasks, but I also wouldn't be able to draw any important conclusions from success û other than the NN can be evolved to solve complex, multi-step, tasks, which has already been established. I wouldn't view this type of tool use as anything like our tool use or believe that it represented a significant advance.

I also think that the authors should consider the literature on self-assembling robots. Is a self-assembling robot not tool using? After all it is adding mechanical parts to achieve a task. And if it isn't tool using, then what differentiates it from the proposed research.

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

As noted above I am only focusing on the technical aspects.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

Summary Statement

This proposed approaches are technically sound, but I do not believe that positive results would significantly expand our knowledge.

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Organization: Texas A&M Engineering Experiment Station

Review #5

Proposal Number:

1617826

NSF Program:

ROBUST INTELLIGENCE

Principal Investigator:

Choe, Yoonsuck

Proposal Title:

RI: Small: Autonomous Construction and Use of Simple to Complex Tools

Rating:

Good

REVIEW:

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to intellectual
merit.

The proposal focuses on the autonomous construction and use of tools by a problem-solving sensorimotor agent. This can be viewed as an instance of learning effective problem-solving sequences of behaviors, specialized to a sensorimotor agent manipulating tools. The proposal is to evolve neural controllers building on and extending existing NEAT architectures. The plan involves developing these ideas via an increasingly complex sequence of tasks D.1 - D.4.

Autonomy is achieved via evolving neural controllers via fitness feedback. So, a key element is the design of fitness landscapes that guide the system toward appropriate behaviors. In addition, the ability to learn task sequences requiring the use of subtasks typically requires aspects of shaping and internal modularity. Both require significant designer input. These issues are alluded to but not directly addressed.

Complex behaviors of this sort are often acquired in humans and animals by imitation. Is the goal here to evolve novel behaviors or would some sort of blending in of learning by demonstration be a more effective approach?

In the context of the five review elements, please
evaluate the strengths and weaknesses of the proposal with respect to broader impacts.

The last task, D.5 is puzzling. It seems to be motivated by the belief that analyses of the internal network dynamics will generate deeper and more general insights into tool use. It appears to draw on variations of neuroscience techniques used to characterize neural network activity. There may be something here worth pursuing but it's not clear.

Please evaluate the strengths and
weaknesses of the proposal with respect to any additional solicitation-specific review criteria, if
applicable

Summary Statement

The proposal is well-organized, well-reasoned and includes a sound evaluation plan. The PI is qualified and well-positioned to conduct the proposed research. The available university facilities are sufficient to carry out the proposed research with the proposed budget.

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