URECA APPLICATION – ASSISTANT

Undergraduate Research Center
MTSU Office of Research

An electronic copy is preferred. **The application must be assembled in checklist order and emailed to Julie.Gannon@mtsu.edu before 4:30 p.m. on the submission deadline date.** If unable to email, please deliver one copy to ING 014C. If you have questions, talk to your faculty mentor or contact the Undergraduate Research Center at 494-7848, or Julie.Gannon@mtsu.edu.

ASSISTANT APPLICATION CHECKLIST	Student's Initials
1. Student Information Page	GMD
2. Faculty Mentor Information and Endorsement	GMD
3. Budget Sheet	GMD
a. Budget documentation (if applicable)	N/A
4. Project proposal (2 pages)	GMD
a. Proposal was written by the student	GMD
5. Time schedule (one page) – This is **not** your class schedule. This is a schedule of tasks related to your project	GMD
6. Academic transcript (unofficial from Pipeline - include **current** semester)	GMD
7. Travel Authorization if travel is being requested	N/A

Signature Statement

By signing below, I (the student) certify that all information provided in the application is accurate and not plagiarized.

Grayson M. Dukes
Student Signature

1/27/16
Date

URECA ASSISTANT APPLICATION

(To be completed by the student. PLEASE TYPE)

Student Information:

Name: Grayson M. Dubois **M #:** 01246708

Address: 2847 Middle Tennessee Boulevard **Telephone Number:** (615) 318-5859

Street

Murfreesboro, TN 37130

City, State, Zip Code **Email Address:** gmd2n@mtmail.mtsu.edu

Major: Computer Science **Minor:** Mathematics

Mentor: Dr. Joshua Phillips **Previous URECA funding:** N/A

Semester, year, level:

Classification:
- ☐ **Freshman**
- ☐ **Sophomore**
- ☑ **Junior**
- ☐ **Senior**

Expected Graduate Date: May 2017

Cumulative GPA: 3.818 **Major GPA:** 4.00

Project Title: Holographic Reduced Representations for Working Memory Concept Encoding

Project Begin Date: February 11 2016 **Project End Date:** May 5 2016

☑ Yes ☐ No I will be a full-time undergraduate student during the project period.

If not, please explain.

URECA APPLICATION – FACULTY MENTOR

(To be completed by faculty mentor. If you have questions, call Julie Gannon at 494-7848.)

Faculty Mentor Information:

Name: Dr. Joshua L. Phillips **Rank:** Assistant Professor

College: CBAS **Department:** Computer Science

Telephone: 615-494-7965 **M#:** 00058505

Email Address: Joshua.Phillips@mtsu.edu

Is IRB Approval Required? ☐ Yes ☑ No

If yes, has it been secured? ☐ Yes ☑ No

Is Performance License, Royalties, or Copyright Permission Required? ☑ Yes ☐ No

If yes, has it been secured? ☐ Yes ☑ No

Faculty Mentor Endorsement

☑ I agree to mentor this student on this project.

☑ I believe that this student is likely to finish the project and that it is a good use of University money.

☑ I have emailed / spoken with my department chair to make him/her aware of project and he/she is supportive of the project and my involvement as a faculty mentor.

Mentor Signature

01/27/2016

Date

URECA BUDGET

(To be developed in consultation with faculty mentor)

Stipend

☒ URECA **Assistant** (designed for one semester) Hours expected: 60 hours **Stipend: $500**

Other Expenses

Many proposals do not warrant other expenses. If the project requires supplies and/or travel funding, departmental support is expected, especially for research that counts toward course credit. If departmental support does not cover all necessary expenses, you may request URECA support below.

SUPPLIES: All requested supply funds must be associated directly with the proposed project and be clearly and fully documented. This documentation should include a justification (explanation of why the supplies are necessary) and proof of costs (copy of webpage or catalog page). Awards for supplies are limited to $300.

Expense Item	Estimated Cost (should include estimated shipping)
	$
	$
	$
	$
Total Other Expenses	$ 0.00

TRAVEL: All requested travel funds must be associated directly with the proposed project and be clearly and fully documented. This documentation should include a justification (explanation of why the travel is necessary) and a Travel Authorization form which can be found at http://www.mtsu.edu/boffice/forms.php#as. Travel funds are limited to $400 for domestic travel and $500 for international travel. Requests for travel to present results should not be included with this application.

Travel Funds Requested

☐ Yes

☑ No

If yes, amount requested: _____

URECA PROPOSAL

(To be completed in collaboration with faculty mentor but written by the student)

Prepare a statement (12- point font, double-spaced, 2-page maximum, excluding figures and tables or 550 words if figures accompany text) of the proposed project, including the following:

Student Name
Project Title
Project objective(s)
Description of your duties/responsibilities
Significance of the project to your academic development in this field

Please keep in mind that the reviewers of this application are drawn from several disciplines. Your statement should be written in a manner that a layperson can understand.

This page is for informational purposes only. Please do not start your proposal on this page.

Holographic Reduced Representation for Working Memory Concept Encoding
Grayson M. Dubois

The field of artificial intelligence (AI) is synergistic with a wide range of disciplines but artificial neural networks (ANNs) is perhaps the most prolific subfield. Not only are biological principles of neural computation and neuroanatomy adapted to solve engineering problems, but ANNs also serve as formal, testable hypotheses of brain function and learning in the cognitive sciences. Still, since ANN models often employ distributed encoding (DE), most have limited application in other areas of AI where symbolic encoding (SE) is the norm (e.g. planning, reasoning, robotics).

For example, there is extensive evidence that the brain contains a working memory (WM) system that actively maintains a small amount of task-essential information that focuses attention on the most task-relevant features, supports learning that transfers across tasks, limits the search space for perceptual systems, provides a means to avoid the out-of-sight/out-of-mind problem and more robust behavior in the face of irrelevant events [1,2]. The prefrontal cortex and mesolimbic dopamine system have been implicated as the functional components of WM in humans and animals, and biologically-based ANNs for WM have been developed based on electrophysiological, neuroimaging, and neuropsychological studies [3]. A software library, the working memory toolkit (WMtk), was developed to aid the integration of ANN-based WM into robotic systems by mitigating the details of ANN design and providing a simple DE interface [4].

The DE/SE distinction is problematic for the WMtk since DE/SE conversion needs to be programmed directly by the user and tuned specifically to each learning task, but a technique called holographic reduced representation (HRR) [5] may overcome these limitations. HRRs provide a framework for creating and combining symbolic concepts using a distributed formalism that is compatible with ANNs. By replacing the DE interface of the WMtk with an HRR interface, DE/SE conversion would be automated, concepts learned from one task would naturally carry over to new tasks, and additional cognitive phenomena (e.g. chunking) may be investigated. Therefore, our specific

aim is to develop and test a holographic reduced representation engine that integrates with the Working Memory toolkit.

Work on this project can be separated into three phases:

1) Gathering information / background for HRRs and HRR generation. I will need to spend the first month of this project researching methods for generating HRRs, and manipulating them to encode and decode conjunctive concepts using circular convolution. I will identify the mathematical formulas necessary and organize the steps required to achieve encoding and decoding of HRRs.

2) Developing a conjunctive encoding engine. Eventually, I will have enough information to write the algorithm for conjunctively encoding HRRs, and will create a library in C++ that can be included in any future projects.

3) Developing a conjunctive decoding engine. As decoding is much more complicated than encoding, I will create the decoding capabilities of the engine last. Using the information gathered in Phase 1, I will write and optimize the algorithm for decoding HRRs, and add it to the HRR generation engine created in Phase 2.

The resulting engine will augment the WMtk by automating the concept encoding process for the user, making the design of agents using the toolkit more user-friendly for researchers in the fields of AI and the cognitive sciences.

Through this project, I will gain experience using research methods in the field of artificial intelligence as well as developing software that utilizes machine learning algorithms. The skills I obtain from working on this project will be especially useful in my future academic career. I am writing my undergraduate Honors thesis on our results. This will be beneficial when I pursue a PhD. in Computer Science, after which I will continue research in neural networks and machine learning methods based on biological systems while also teaching at the university level.

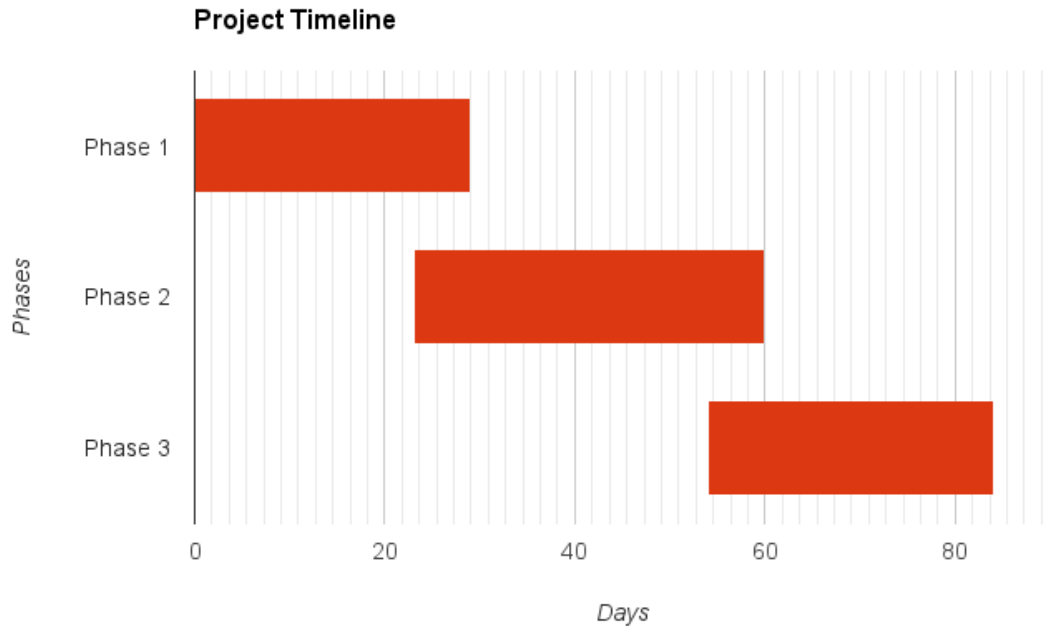

Figure 1 – Phase 1: Gathering background information and learning methods for generating HRRs. Phase 2: Developing the software library and writing code for a conjunctive encoding engine. Phase 3: Adding conjunctive decoding capabilities to the HRR generation engine and finalizing the library to make it available for use in future projects.

References:

[1] A. Baddeley. *Working Memory*, volume 11 of *Oxford Psychology Series*. Clarendon Press, Oxford, 1986.
[2] N. C. Waugh and D. A. Norman. Primary memory. *Psychological Review*, 72:89–104, 1965.
[3] R. C. O'Reilly, D. C. Noelle, T. S. Braver, and J. D. Cohen. Prefrontal cortex and dynamic categorization tasks: Representational organization and neuromodulatory control. *Cerebral Cortex*, 12:246–257, 2002.
[4] J. L. Phillips and D. C. Noelle. Working Memory for Robots: Inspirations from Computational Neuroscience. in *Proceedings of the 5th International Conference on Development and Learning*, 2006.
[5] T. A. Plate. Holographic reduced representations. *IEEE Trans. Neural Networks*, vol. 6, no. 3, pp. 623–641, May 1995.

Student Academic Transcript

This is not an official transcript. Courses which are in progress may also be included on this transcript.

TRANSCRIPT KEY: The repeat indicator column denoted by an "R" after the Quality Points column translates as follows:
E = Excluded from GPA and Earned Hours
A = Included in GPA, but not Earned hours
I = Included in GPA and Earned Hours
F = Frozen and exempt from repeat processing (i.e., repeatable courses)
. = Excluded from GPA and Earned Hours – Academic Fresh Start

M01246708 Grayson McKenzie Dubois

Information for Grayson M. Dubois

Institution Credit Transcript Totals Courses in Progress

Transcript Data

STUDENT INFORMATION

Student Type: Continuing

Curriculum Information

Current Program

Bachelor of Science

College: Basic and Applied Sciences

Major and Department: Computer Science, Computer Science

Major Concentration: Professional Computer Science

Minor: Mathematics

***Transcript type:Advising-Unofficial Transcript is NOT Official ***

INSTITUTION CREDIT -Top-

Term: Fall 2013

College: Basic and Applied Sciences

Major: Computer Science

Student Type: New First Time Freshman

Academic Standing: Good Standing

Additional Standing: Dean's List

Subject	Course	Level	Title	Grade	Credit Hours	Quality Points	R	CEU Contact Hours
CSCI	1170	UG	Computer Science I	A	4.000	16.000		
ENGL	1010	UG	(HONORS) Expository Writing	A	3.000	12.000		
ET	2310	UG	Computer-Assist Draft Design I	B	3.000	9.000		
MATH	1910	UG	Calculus I	B	4.000	12.000		
UNIV	1010	UG	(HONORS) University Seminar	A	3.000	12.000		

Term Totals (Undergraduate)

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Current Term:	17.000	17.000	17.000	17.000	61.000	3.588
Cumulative:	17.000	17.000	17.000	17.000	61.000	3.588

Term: Spring 2014

College: Basic and Applied Sciences

Major: Computer Science

Student Type: Continuing

Academic Standing: Good Standing

Additional Standing: Dean's List

Subject	Course	Level	Title	Grade	Credit Hours	Quality Points	R	CEU Contact Hours
CSCI	2170	UG	Computer Science II	A	4.000	16.000		

ENGL	1020	UG	(HONORS) Research and Argumentative Writing	B+	3.000	9.990	
HIST	2010	UG	(HONORS) Survey of United States History I	A	3.000	12.000	
MATH	1920	UG	Calculus II	A	4.000	16.000	
UH	3200	UG	Visiting Artist's Seminar: Playwriting with Victoria Stewart and Cory Hinkle	P	1.000	0.000	

Term Totals (Undergraduate)

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Current Term:	15.000	15.000	15.000	14.000	53.990	3.856
Cumulative:	32.000	32.000	32.000	31.000	114.990	3.709

Term: Fall 2014

College: Basic and Applied Sciences
Major: Computer Science
Student Type: Continuing
Academic Standing: Good Standing
Additional Standing: Dean's List

Subject	Course	Level	Title	Grade	Credit Hours	Quality Points	R	CEU Contact Hours
CHEM	1110	UG	(HONORS) General Chemistry I	A	4.000	16.000		
COMM	2200	UG	(HONORS) Fundamentals of Communication	B+	3.000	9.990		
CSCI	3080	UG	Discrete Structures	A	3.000	12.000		
HIST	2030	UG	(HONORS)Tennessee History	A	3.000	12.000		

Term Totals (Undergraduate)

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Current Term:	13.000	13.000	13.000	13.000	49.990	3.845
Cumulative:	45.000	45.000	45.000	44.000	164.980	3.750

Term: Spring 2015

College: Basic and Applied Sciences
Major: Computer Science
Student Type: Continuing
Academic Standing: Good Standing
Additional Standing: Dean's List

Subject	Course	Level	Title	Grade	Credit Hours	Quality Points	R	CEU Contact Hours
CHEM	1120	UG	(HONORS)General Chemistry II	A	4.000	16.000		
CSCI	3110	UG	Algorithms and Data Structures	A	3.000	12.000		
CSCI	3160	UG	Intro to Assembly Language	A	3.000	12.000		
MATH	2050	UG	Probability and Statistics	A	3.000	12.000		
PSY	1410	UG	General Psychology	B	3.000	9.000		

Term Totals (Undergraduate)

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Current Term:	16.000	16.000	16.000	16.000	61.000	3.813
Cumulative:	61.000	61.000	61.000	60.000	225.980	3.766

Term: Fall 2015

College: Basic and Applied Sciences
Major: Computer Science
Student Type: Continuing
Academic Standing: Good Standing
Additional Standing: Dean's List

Subject	Course	Level	Title	Grade	Credit Hours	Quality Points	R	CEU Contact Hours
BIOL	1110	UG	(HONORS) General Biology	A	4.000	16.000		
CSCI	3130	UG	Assembly and Computer Org	A	4.000	16.000		
CSCI	3250	UG	Operating Systems	A	3.000	12.000		
MATH	2010	UG	Elements of Linear Algebra	A	3.000	12.000		
SOC	1010	UG	Introductory Sociology	A	3.000	12.000		

Term Totals (Undergraduate)

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Current Term:	17.000	17.000	17.000	17.000	68.000	4.000

Cumulative:	78.000	78.000	78.000	77.000	293.980	3.818

Unofficial Transcript

TRANSCRIPT TOTALS (UNDERGRADUATE) -Top-

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Total Institution:	78.000	78.000	78.000	77.000	293.980	3.818
Total Transfer:	0.000	0.000	0.000	0.000	0.000	0.000
Overall:	78.000	78.000	78.000	77.000	293.980	3.818

	Attempt Hours	Passed Hours	Earned Hours	GPA Hours	Quality Points	GPA
Institution Combined:	78.000	78.000	78.000	77.000	293.980	3.818
Transfer Combined:	0.000	0.000	0.000	0.000	0.000	0.000
Overall Combined:	78.000	78.000	78.000	77.000	293.980	3.818

Unofficial Transcript

COURSES IN PROGRESS -Top-

Term: Spring 2016

College:	Basic and Applied Sciences
Major:	Computer Science
Student Type:	Continuing

Subject	Course	Level	Title	Credit Hours
CSCI	3037	UG	Computer Languages: Visual Programming	3.000
CSCI	3210	UG	Theory of Programming Languages	3.000
MATH	3180	UG	Introduction to Numerical Analysis	3.000
PHIL	1030	UG	Introduction to Philosophy	3.000
PHIL	3170	UG	Ethics and Computing Technology	3.000
UH	3000	UG	University Honors Lecture Series: The Value of a Liberal Education	1.000
UH	4900	UG	Honors Thesis Tutorial	1.000

Unofficial Transcript

RELEASE: 8.1