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4. TITLE AND SUBTITLE Final Report: Intelligent Information Networks: Young Investigator Program: Modeling, Sampling, and Analyzing Adversarial Social Networks	5a. CONTRACT NUMBER W911NF-18-1-0047
	5b. GRANT NUMBER
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6. AUTHORS	5d. PROJECT NUMBER
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	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES AND ADDRESSES Syracuse University Office of Research 113 Bowne Hall Syracuse, NY 13244 -1200	8. PERFORMING ORGANIZATION REPORT NUMBER
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	11. SPONSOR/MONITOR'S REPORT NUMBER(S) 72265-CS-YIP.11

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13. SUPPLEMENTARY NOTES The views, opinions and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision, unless so designated by other documentation.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:	17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Sucheta Soundarajan
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU	19b. TELEPHONE NUMBER 315-443-2368

RPPR Final Report

as of 02-Aug-2021

Agency Code: 21XD

Proposal Number: 72265CSYIP

Agreement Number: W911NF-18-1-0047

INVESTIGATOR(S):

Name: Ph.D Sucheta Soundarajan

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DUNS Number: 002257350

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Report Date: 31-Jul-2021

Date Received: 29-Jul-2021

Final Report for Period Beginning 02-Jan-2018 and Ending 30-Apr-2021

Title: Intelligent Information Networks: Young Investigator Program: Modeling, Sampling, and Analyzing Adversarial Social Networks

Begin Performance Period: 02-Jan-2018

End Performance Period: 30-Apr-2021

Report Term: 0-Other

Submitted By: Ph.D Sucheta Soundarajan

Email: susounda@syr.edu

Phone: (315) 443-2368

Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees: 5

STEM Participants: 7

Major Goals: The major goal of this project is to propose algorithms for collecting and analyzing data from adversarial social networks. An adversarial social network is one in which some or all individuals in the network are hostile against the data collector or analyst, and so may provide information that is deliberately misleading.

Specific goals within the project included the following: (1) Designing and analyzing network data collection games, including a game theoretical analysis of when data can be collected accurately. Experimental analysis of these games. (2) Creation of robust network sampling and re-sampling algorithms to collect data from adversarial social networks. Such algorithms take advantage of results from the network data collection games. Development of sampling/re-sampling algorithms that use multi-source information to reinforce and correct observed data. (3) Development of community detection and influential node location algorithms on adversarial network sampling.

Accomplishments: The Network Data Collection Game

The Network Data Collection game is designed to study interactions between a data collector and a set of adversarial nodes in social networks. We developed the "Werewolves and Villagers" game to run online experiments to collect data about how people interact with a data collector. This project was in collaboration with Dr. Raluca Gera, a mathematician at the Naval Postgraduate School.

The game set up is as follows: A village social network consists of villagers and a pack of werewolves (adversarial nodes) hiding among these villagers. An investigator attempts to identify these werewolves by querying nodes about their neighbors. Nodes are allowed to report misinformation to the data collector to mislead the investigation.

The investigator queries individuals whether their neighbors are werewolves or not. Participants are allowed to lie about neighbors' attributes. Participants need to consider what rewards and penalties are associated with each neighbor, how likely that the investigator will investigate the neighbor.

We tested various hypotheses, including whether participants are loyal their group, if they try to protect members of the group at their own cost, and if they consider the hierarchy of the group when making decisions. Results were published at the SBP-BRIMS conference [9].

Confidence Measure for Node Classification Algorithms

Node classification algorithms are designed to address classification problems in networked data. For example, we

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may want to identify criminal nodes in an adversarial social network by using their attributes and topology. In such situations, it is useful to have not just the prediction but also a confidence measure. We propose a technique based on conformal prediction to identify such confidence bounds on node classifications; additionally, we show that using conformal prediction can improve the accuracy of node classification methods by up to 30% [10].

Multi-Layer Network Crawling

We considered the problem of crawling data from multi-layer networks. This work was published in AAAI and the ACM TKDD journal. This work was in collaboration with Dr. Jeremy Wendt from Sandia National Labs.

A multi-layer network is a network containing multiple layers of edges, each corresponding to a different type of relationship. Different layers may have different data collection cost and accuracies.

We proposed an algorithm called MultiComSampling (MCS) for such tasks [6]. MCS infers the relationship between the layer of interest and the other layers that are cheaper to explore, and then uses the structure of the cheap layers to determine which nodes in the layer of interest to query.

As an extension, we considered cases when nodes have different attributes, when the communities are overlapping, and different types of errors caused by adversarial noise. We proposed MCS+ to handle such cases, and demonstrate that it outperforms the best baseline algorithm by a factor of up to 3x [7].

While working on this project, we observed that existing network crawling algorithms tend to fall into two categories: (1) those that easily transition between regions of a graph, while failing to thoroughly explore each region, and (2) those that thoroughly explore individual regions, but then have difficulty moving to a new region. To capture the best of both worlds, even in cases where there is a high degree of separation between regions, we introduced the DenseEx network crawling algorithm [2].

k-Core Resilience

k-cores are an important way to identify central regions and nodes within social networks. In this project, we studied how random deletion of nodes or edges can affect a network's core structure; and moreover, how one can add edges to the network to bolster its existing core structure. This project was published in [4].

We introduced two ways to evaluate the importance of a node to a network's core structure: Core Influence, which measures how dependent other nodes are on that node, and Core Strength, which measures how resilient a node's own core number is. We then evaluated networks' k-core resilience overall to evaluate their robustness against attacks.

Network Data Protection

In many applications, one may wish to conceal certain nodes in a network from a data collector. For example, in a local computer network, it is important to protect servers that hold sensitive information. We consider the problem of determining which edges in a network should be removed by a data protector so as to best conceal the nodes of interest from a crawler.

This problem can be modelled using game theory, where the players are the crawler and the data protector. We model the crawler as a random walk-based or BFS-type algorithm. We propose a method based on particle swarm optimization to generate a transition probability matrix such that a random walk based on that matrix minimizes the number of nodes queried. The data protector then uses this matrix to solve the problem as an optimization problem.

This work was published in the 2021 ACM Web Science Conference (WebSci) [8]. It was selected as one of the top papers in the conference and an extended version was invited for publication in The Web Journal.

Other Work

We studied the anchored k-core problem, in which an algorithm selects "anchor" nodes to keep in an "anchored" k-core. We use our earlier work on resilience to assign scores to calculate an "anchor score" for each node, and show experimentally that our algorithm selects anchors that significantly outperform the current state-of-the-art [5]. We have also published a paper on characterizing network crawling algorithms [1]. We show that crawling algorithms are sensitive to various graph properties. Finally, we proposed a novel sampling robustness measure, which quantifies how well a crawling algorithm can explore a network when edges from that network are hidden [3].

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- [1] Katchaguy Areekijseree and Sucheta Soundarajan. "Crawling Complex Networks: An Experimental Evaluation of Data Collection Algorithms and Network Structural Properties." *Journal of Web Science (JWS)*. 2019.
- [2] Katchaguy Areekijseree and Sucheta Soundarajan. "DE-Crawler: A Densification-Expansion Algorithm for Online Data Collection". *IEEE/ACM International Conference on Advances in Social Network Analysis and Mining (ASONAM)*. 2018.
- [3] Katchaguy Areekijseree and Sucheta Soundarajan. "Measuring the Sampling Robustness of Complex Networks." *IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM)*. 2019.
- [4] Ricky Laishram, Ahmet Erdem Sariyuçe, Tina Eliassi-Rad, Ali Pinar, and Sucheta Soundarajan. "Measuring and Improving the Core Resilience of Networks." *The Web Conference (WWW)*. 2018.
- [5] Ricky Laishram, Ahmet Erdem Sariyuçe, Tina Eliassi-Rad, Ali Pinar, and Sucheta Soundarajan. "Residual Core Maximization: An Efficient Algorithm for Maximizing the Size of the k-Core." *SIAM Conference on Data Mining (SDM)*. 2020.
- [6] Ricky Laishram, Jeremy D. Wendt, and Sucheta Soundarajan. "Crawling the Community Structure of Multiplex Networks." *AAAI Conference on Artificial Intelligence (AAAI)*. 2019.
- [7] Ricky Laishram, Jeremy D. Wendt, and Sucheta Soundarajan. "MCS+: An Efficient Algorithm for Crawling the Community Structure in Multiplex Networks." In submission to *ACM TKDD*.
- [8] Ricky Laishram, Jeremy D. Wendt, and Sucheta Soundarajan. "Net Protect: Network Perturbations to Hide Target Nodes." *ACM Conference on Web Science*, 2021.
- [9] Pivithuru Wijegunawardana, Mario Taglic, Raluca Gera, and Sucheta Soundarajan. "An Experimental Framework for Characterizing Adversarial Behavior in Social Networks", *SBP-BRiMS*, July 2019
- [10] Pivithuru Wijegunawardana, Raluca Gera, and Sucheta Soundarajan. "Node Classification with Bounded Error Rates." *Conference on Complex Networks (CompleNet)*. 2020.

Training Opportunities: This grant has supported five PhD students. These students participated in research, writing papers, conference presentations, and mentoring undergraduate students. Two of the PhD students (K. Areekijseree and P. Wijegunawardana) graduated in fall 2019, and a third (R. Laishram) graduated in summer 2020. A fourth (P. Hozhabrierdi) is planning to graduate in spring/summer 2022.

This grant has also provided several opportunities for undergraduate research. One published paper (*SBP-BRiMS* 2019) included an undergraduate author.

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Results Dissemination: This grant has resulted in the publications listed below. Three additional submissions are planned for later in 2021.

[1] Katchaguy Areekijserree and Sucheta Soundarajan. "Crawling Complex Networks: An Experimental Evaluation of Data Collection Algorithms and Network Structural Properties." Journal of Web Science (JWS). 2019.

[2] Katchaguy Areekijserree and Sucheta Soundarajan. "DE-Crawler: A Densification-Expansion Algorithm for Online Data Collection". IEEE/ACM International Conference on Advances in Social Network Analysis and Mining (ASONAM). 2018.

[3] Katchaguy Areekijserree and Sucheta Soundarajan. "Measuring the Sampling Robustness of Complex Networks." IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining (ASONAM). 2019.

[4] Ricky Laishram, Ahmet Erdem Sariyuçe, Tina Eliassi-Rad, Ali Pinar, and Sucheta Soundarajan. "Measuring and Improving the Core Resilience of Networks." The Web Conference (WWW). 2018.

[5] Ricky Laishram, Ahmet Erdem Sariyuçe, Tina Eliassi-Rad, Ali Pinar, and Sucheta Soundarajan. "Residual Core Maximization: An Efficient Algorithm for Maximizing the Size of the k-Core." SIAM Conference on Data Mining (SDM). 2020.

[6] Ricky Laishram, Jeremy D. Wendt, and Sucheta Soundarajan. "Crawling the Community Structure of Multiplex Networks." AAAI Conference on Artificial Intelligence (AAAI). 2019.

[7] Ricky Laishram, Jeremy D. Wendt, and Sucheta Soundarajan. "MCS+: An Efficient Algorithm for Crawling the Community Structure in Multiplex Networks." In submission to ACM TKDD.

[8] Ricky Laishram, Jeremy D. Wendt, and Sucheta Soundarajan. "Net Protect: Network Perturbations to Hide Target Nodes." ACM Conference on Web Science, 2021.

[9] Pivithuru Wijegunawardana, Mario Taglic, Raluca Gera, and Sucheta Soundarajan. "An Experimental Framework for Characterizing Adversarial Behavior in Social Networks", SBP-BRiMS, July 2019

[10] Pivithuru Wijegunawardana, Raluca Gera, and Sucheta Soundarajan. "Node Classification with Bounded Error Rates." Conference on Complex Networks (CompleNet). 2020.

Honors and Awards: Our publication in the 2021 ACM Web Science conference was selected as one of the top papers of that conference, and so was invited for publication in a special issue of The Web Journal.

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI

Participant: Sucheta Soundarajan

Person Months Worked: 7.00

Project Contribution:

National Academy Member: N

Funding Support:

Participant Type: Graduate Student (research assistant)

Participant: Ricky Laishram

Person Months Worked: 15.00

Project Contribution:

Funding Support:

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National Academy Member: N

Participant Type: Graduate Student (research assistant)

Participant: Pivithuru Wijegunawardana

Person Months Worked: 11.00

Funding Support:

Project Contribution:

National Academy Member: N

Participant Type: Graduate Student (research assistant)

Participant: Pegah Hozhabrierdi

Person Months Worked: 3.00

Funding Support:

Project Contribution:

National Academy Member: N

Participant Type: Graduate Student (research assistant)

Participant: Katchaguy Areekjserree

Person Months Worked: 6.00

Funding Support:

Project Contribution:

National Academy Member: N

Participant Type: Graduate Student (research assistant)

Participant: Weixiang Wang

Person Months Worked: 8.00

Funding Support:

Project Contribution:

National Academy Member: N

Participant Type: Undergraduate Student

Participant: Maduakolam Onyewu

Person Months Worked: 1.00

Funding Support:

Project Contribution:

National Academy Member: N

Participant Type: Undergraduate Student

Participant: Raymond Zhu

Person Months Worked: 1.00

Funding Support:

Project Contribution:

National Academy Member: N

ARTICLES:

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as of 02-Aug-2021

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 1-Published

Journal: The Journal of Web Science

Publication Identifier Type: DOI

Publication Identifier: 10.34962/jws-69

Volume: 6

Issue:

First Page #:

Date Submitted: 7/7/21 12:00AM

Date Published: 6/25/19 4:00AM

Publication Location:

Article Title: Crawling Complex Networks: An Experimental Evaluation of Data Collection Algorithms and Network Structural Properties

Authors: Katchaguy Areekijserree, Sucheta Soundarajan

Keywords: network crawling

Abstract: In this work, we demonstrate that the performance of network crawling methods is highly dependent on the structural properties of the network. To do that, we perform a detailed, hypothesis-driven analysis of the performance of eight popular crawling methods with respect to the task of maximizing node coverage. We perform experiments on both directed and undirected networks, under five different query response models: complete, paginated, partial, in-out, and out responses. We identify three important network properties: community separation, average community size, and average node degree. We begin by performing controlled experiments on synthetic networks, and then verify our observations on real networks. Finally, we provide guidelines to data collectors on how to select an appropriate crawling method for a particular network.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support: Y

Publication Type: Journal Article Peer Reviewed: Y **Publication Status:** 2-Awaiting Publication

Journal: ACM Transactions on Knowledge Discovery from Data

Publication Identifier Type:

Publication Identifier:

Volume:

Issue:

First Page #:

Date Submitted: 7/7/21 12:00AM

Date Published:

Publication Location:

Article Title: MCS+: An Efficient Algorithm for Crawling the Community Structure in Multiplex Networks

Authors: Ricky Laishram, Jeremy D. Wendt, Sucheta Soundarajan

Keywords: multiplex networks, community detection, network crawling, multi-armed bandit

Abstract: In this paper, we consider the problem of crawling a multiplex network to identify the community structure of a layer-of-interest. A multiplex network is one where there are multiple types of relationships between the nodes. In many multiplex networks, some layers might be easier to explore (in terms of time, money, etc.). We propose MCS+, an algorithm that can use the information from the easier to explore layers to help in the exploration of a layer-of-interest that is expensive to explore. We consider the goal of exploration to be generating a sample that is representative of the communities in the complete layer-of-interest.

Distribution Statement: 2-Distribution Limited to U.S. Government agencies only; report contains proprietary info

Acknowledged Federal Support: Y

CONFERENCE PAPERS:

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published

Conference Name: the 2018 World Wide Web Conference

Date Received: 30-Aug-2018

Conference Date: 23-Apr-2018

Date Published:

Conference Location: Lyon, France

Paper Title: Measuring and Improving the Core Resilience of Networks

Authors: Ricky Laishram, Ahmet Erdem Sariyuce, Tina Eliassi-Rad, Ali Pinar, Sucheta Soundarajan

Acknowledged Federal Support: Y

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Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: 2018 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining
Date Received: 08-May-2019 Conference Date: 28-Aug-2018 Date Published:
Conference Location: Barcelona, Spain
Paper Title: DE-Crawler: A Densification-Expansion Algorithm for Online Data Collection
Authors: Katchaguy Areekijserree and Sucheta Soundarajan
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: AAAI Conference on Artificial Intelligence (AAAI)
Date Received: 17-Aug-2019 Conference Date: 07-Jan-2019 Date Published:
Conference Location: Honolulu, Hawaii
Paper Title: Crawling the Community Structure of Multiplex Networks.
Authors: Ricky Laishram, Jeremy Wendt, Sucheta Soundarajan
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: IEEE#x2f;ACM International Conference on Advances in Social Networks Analysis and Mining #x28;ASONAM#x29;
Date Received: 19-Aug-2020 Conference Date: 27-Nov-2018 Date Published:
Conference Location: Vancouver, Canada
Paper Title: Measuring the Sampling Robustness of Complex Networks
Authors: Katchaguy Areekijserree, Sucheta Soundarajan
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: An Experimental Framework for Characterizing Adversarial Behavior in Social Networks (SBP-BRIMS)
Date Received: 17-Aug-2019 Conference Date: 09-Jul-2019 Date Published: 09-Jul-2019
Conference Location: Washington, DC, USA
Paper Title: An Experimental Framework for Characterizing Adversarial Behavior in Social Networks
Authors: Pivithuru Wijegunawardana, Mario Taglic, Raluca Gera, Sucheta Soundarajan
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: SIAM Conference on Data Mining
Date Received: 19-Aug-2020 Conference Date: 07-May-2020 Date Published:
Conference Location: cancelled due to Covid
Paper Title: Residual Core Maximization#x3a; An Efficient Algorithm for Maximizing the Size of the k-Core
Authors: Ricky Laishram, Ahmet Erdem Sariyuce, Tina Eliassi-Rad, Ali Pinar, Sucheta Soundarajan
Acknowledged Federal Support: **Y**

Publication Type: Conference Paper or Presentation **Publication Status:** 1-Published
Conference Name: Conference on Complex Networks
Date Received: 19-Aug-2020 Conference Date: 19-Aug-2020 Date Published:
Conference Location: virtual due to Covid
Paper Title: Node Classification with Bounded Error Rates
Authors: Pivithuru Wijegunawardana, Raluca Gera, Sucheta Soundarajan
Acknowledged Federal Support: **Y**

RPPR Final Report
as of 02-Aug-2021

Publication Type: Conference Paper or Presentation

Publication Status: 1-Published

Conference Name: WebSci '21: WebSci '21 13th ACM Web Science Conference 2021

Date Received: 07-Jul-2021

Conference Date: 21-Jun-2021

Date Published:

Conference Location: Virtual Event United Kingdom

Paper Title: NetProtect: Network Perturbations to Protect Nodes against Entry-Point Attack

Authors: Ricky Laishram, Pegah Hozhabrierdi, Jeremy D. Wendt, Sucheta Soundarajan

Acknowledged Federal Support: **Y**

Partners

,

Dr. Jeremy Wendt, Sandia National Laboratories, Albuquerque, New Mexico. Dr. Raluca Gera, Naval Postgraduate

I certify that the information in the report is complete and accurate:

Signature: Sucheta Soundarajan

Signature Date: 7/29/21 3:10PM

All major accomplishments have already been described in the “Accomplishments” and “Dissemination” sections.

REPORT OF INVENTIONS AND SUBCONTRACTS
(Pursuant to "Patent Rights" Contract Clause) (See Instructions on back)

*Form Approved
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 Expires Jan 31, 2008*

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1.a. NAME OF CONTRACTOR/SUBCONTRACTOR Syracuse University		c. CONTRACT NUMBER W911NF-18-1-0047	2.a. NAME OF GOVERNMENT PRIME CONTRACTOR US Army Research Office		c. CONTRACT NUMBER W911NF-18-1-0047	3. TYPE OF REPORT (X one) a. INTERIM <input type="checkbox"/> b. FINAL <input checked="" type="checkbox"/>	
b. ADDRESS (Include ZIP Code) Office of Sponsored Programs, 211 Lyman Hall Syracuse, NY 13244			d. AWARD DATE (YYYYMMDD) 20180102	b. ADDRESS (Include ZIP Code) 800 Park Office Drive, Suite 4229 Research Triangle Park, NC 27709		d. AWARD DATE (YYYYMMDD) 20180102	4. REPORTING PERIOD (YYYYMMDD) a. FROM 20180102 b. TO 20210430

SECTION I - SUBJECT INVENTIONS

5. "SUBJECT INVENTIONS" REQUIRED TO BE REPORTED BY CONTRACTOR/SUBCONTRACTOR (If "None," so state)

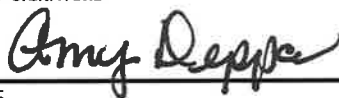
NAME(S) OF INVENTOR(S) <i>(Last, First, Middle Initial)</i> a.	TITLE OF INVENTION(S) b.	DISCLOSURE NUMBER, PATENT APPLICATION SERIAL NUMBER OR PATENT NUMBER c.	ELECTION TO FILE PATENT APPLICATIONS (X) d.				CONFIRMATORY INSTRUMENT OR ASSIGNMENT FORWARDED TO CONTRACTING OFFICER (X) e.	
			(1) UNITED STATES		(2) FOREIGN		(a) YES	(b) NO
			(a) YES	(b) NO	(a) YES	(b) NO		
None								
f. EMPLOYER OF INVENTOR(S) NOT EMPLOYED BY CONTRACTOR/SUBCONTRACTOR			g. ELECTED FOREIGN COUNTRIES IN WHICH A PATENT APPLICATION WILL BE FILED					
(1) (a) NAME OF INVENTOR <i>(Last, First, Middle Initial)</i>	(2) (a) NAME OF INVENTOR <i>(Last, First, Middle Initial)</i>	(1) TITLE OF INVENTION			(2) FOREIGN COUNTRIES OF PATENT APPLICATION			
(b) NAME OF EMPLOYER	(b) NAME OF EMPLOYER							
(c) ADDRESS OF EMPLOYER <i>(Include ZIP Code)</i>	(c) ADDRESS OF EMPLOYER <i>(Include ZIP Code)</i>							

SECTION II - SUBCONTRACTS (Containing a "Patent Rights" clause)

6. SUBCONTRACTS AWARDED BY CONTRACTOR/SUBCONTRACTOR (If "None," so state)

NAME OF SUBCONTRACTOR(S) a.	ADDRESS <i>(Include ZIP Code)</i> b.	SUBCONTRACT NUMBER(S) c.	FAR "PATENT RIGHTS" d.		DESCRIPTION OF WORK TO BE PERFORMED UNDER SUBCONTRACT(S) e.	SUBCONTRACT DATES (YYYYMMDD) f.	
			(1) CLAUSE NUMBER	(2) DATE <i>(YYYYMM)</i>		(1) AWARD	(2) ESTIMATED COMPLETION
None							

SECTION III - CERTIFICATION

7. CERTIFICATION OF REPORT BY CONTRACTOR/SUBCONTRACTOR (Not required if: (X as appropriate))		<input type="checkbox"/> SMALL BUSINESS or	<input type="checkbox"/> NONPROFIT ORGANIZATION
I certify that the reporting party has procedures for prompt identification and timely disclosure of "Subject Inventions," that such procedures have been followed and that all "Subject Inventions" have been reported.			
a. NAME OF AUTHORIZED CONTRACTOR/SUBCONTRACTOR OFFICIAL <i>(Last, First, Middle Initial)</i> Deppa, Amy	b. TITLE Research Administrator	c. SIGNATURE 	d. DATE SIGNED 20210729