Michigan Technological University

FINAL REPORT: DURIP: Acoustic Sensing System and High-Throughput Computing for Environment and Threat Monitoring in Naval Environments Using Machine Learning

Grant Number: N00014-20-1-2793

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I. Equipment

Manufacturer / Model No.	Qty.	Unit Cost	Total
Data Acquisition Systems			
Crystal Instruments CoCo-80X, 8 channel DAQ	1	$12,500	$12,500
Crystal Instruments CoCo-90X, 16 channel DAQ	1	$19,750	$19,750
Acoustic Vector Sensors			
Wilcoxon Sensing Technologies VS-209	2	$11,950.91	$23,901.82
Low Noise Hydrophones			
Teledyne Reson TC4032-1, Hydrophone	5	$4,350	$21,750
Teledyne Reson TC4032-2, Hydrophone	5	$3,870	$19,350
Teledyne Reson EC6076, Input Module	10	$1,593	$15,930
Teledyne Reson TL8144-1, Cable	6	$1,260	$7,560
Teledyne Reson TL8144-30m, Cable	4	$1,440	$5,760
Teledyne Reson TL8142-1, Cable	2	$2,301.60	$4,603.20
Teledyne Reson TL8142-7, Cable	2	$3,092.40	$6,184.80
GPU Server			
Lambda Blade	1	$99,000	$99,000
GPU Workstation			
Lambda Workstation	2	$8,280	$16,560
Network Attached Storage			
DELL PowerVault NX3240	1	$5,455.20	$5,455.20

II. Special circumstances surrounding any change from proposal

None

III. Description of Equipment Use

Grants and contracts on which equipment was used:
The equipment purchased with the funds from this DURIP grant supported 7 DoD contracts/grants, 3 industry contracts, and one NSF grant: a total of nearly $3.9 million in contracts and grants. Five publications, to date, have been published and 9 proposals have been submitted, one of which has been recommended for funding and 2 of which are pending.

SCC-CIVIC-PG Track B: Helping Rural Counties to Enhance Flooding and Coastal Disaster Resilience and Adaptation ($50k), NSF, 2021 (PI: Thomas Oommen, Co-PIs: Timothy C. Havens, Guy Meadows)
GPU workstations and servers to be used in machine learning algorithms for flood resilience prediction tool.

Redesign and Implementation of USDS-Proxy Language – Phase II+Option ($1M), ONR STTR Phase 2, 2021-2023 (Prime: ARiA; MTU PI: Charles Wallace, MTU Co-PIs: Timothy C. Havens, Andrew Barnard, Leo Ureel)
Vector sensors and hydrophones to be used as sensors in demonstration system.

Redesign and Implementation of USDS-Proxy Language ($150k), ONR STTR Phase 1, 2020 (Prime: ARiA; MTU PI: Charles Wallace, MTU Co-PIs: Timothy C. Havens, Andrew Barnard)
Vector sensors and hydrophones to be used as sensors in demonstration system.

Modeling and Algorithm Development for Adaptive Adversarial AI for Complex Autonomy ($430k), SOSSEC / US Army ERDC, 2020-2022 (PI: Timothy C. Havens, Co-PI: Anthony J. Pinar)
GPU workstations and servers used for machine learning of data-derived autonomy and for simulations performed in AirSim/Unreal Engine.

Machine Learning and Artificial Intelligence Using Acoustic Sensors in Connected Vehicles and Roadside Units ($300k), Ford Motor Company, 2020-2021 (PIs: Timothy C. Havens, Andrew Barnard)
GPU workstations and servers used for testing of machine learning algorithms for detection of acoustic events. Data acquisition systems used to collect training data for algorithms.

Defending the Nation's Digital Frontier: Cybersecurity Training for Tomorrow's Officers, Office of Naval Research ($250k), 2020-2021, (PI: Andrew Barnard, Co-PIs: Timothy C. Havens, Laura Brown, Yu Cai)
GPU workstations and servers used for training of ROTC cadets in machine learning and AI methods. Data acquisition systems and hydrophones used to train cadets in sensor systems and data acquisition.

Duty Cycle Aggregation, Warranty Mitigation, and Fleet Prognostics using Customer Usage Data (Part II) ($200k), Ford Motor Company, 2020-2022 (PI: Timothy C. Havens)
GPU workstations and servers used for testing of machine learning algorithms for anomaly detection in powertrain data in customer vehicles.

Algorithms for Look-Down Infrared Target Exploitation – Phase II ($1M), NGA STTR Phase 2, 2020-2022 (Prime: Signature Research, Inc.; MTU PI: Timothy C. Havens)
GPU workstations and servers used for development of machine learning algorithms for detection of military targets in overhead infrared imagery. Workstations are also used for rendering of synthetic infrared image examples used in training algorithms.

Localization, Tracking, and Classification of On-Ice and Underwater Noise Sources Using Machine Learning ($300k), Naval Undersea Warfare Center, 2019-2022 (PI: Timothy C. Havens, Co-PI: Andrew Barnard)
Data acquisition system and vector sensors used for development of machine learning algorithms that can localize anthropogenic sources on- and under-the-ice. GPU workstations and servers used to train machine learning algorithms.

Algorithm Performance Evaluation with Low Sample Size ($50k), NGA STTR Phase I, 2021-2022 (Prime: Signature Research Inc., MTU PI: Timothy C. Havens)
GPU workstations and servers to be used for development of machine learning algorithms for testing of methods that can evaluate classification and detection algorithms with small numbers of test images.

USGS Fisheries Acoustics ($125k), US Geological Survey, 2021-2022 (PI: Christopher Roussi, Co-PI: Andrew Barnard)
Hydrophones and data acquisition systems used to collect ship acoustic signatures to compare with acoustic biomass estimates from unmanned sailing vessels. Objective is to correlate radiated ship noise with biomass estimates to correct for ship effects on fish behavior.

Publications produced using equipment procured from this grant:

1. S.J. Whitaker, **A. Barnard**, G.D. Anderson, and **T.C. Havens** (July, 2021). Recurrent networks for DOA identification of anthropogenic acoustic sources in a shallow water channel using a vector sensor. *J. Acoustical Society of America, 150*(1), 111-119.
2. E. Hedayati, **T.C. Havens**, and J.P Bos (July, 2021). Light field compression by residual CNN-assisted JPEG. *Int J. Conf. Neural Networks*.
3. S. Whitaker, Z. Dekraker, **A. Barnard**, **T.C. Havens**, G.D. Anderson II (July, 2021). Uncertain inference using ordinal classification in deep networks for acoustic localization. *Int. J. Conf. Neural Networks*.
4. N. Hamilton, A. Webb, Z. Dekraker, B. Hendrickson, M. Blanck, E. Nelson, W. Roemer, and **T.C. Havens** (Apr, 2021). Augmentation methods for object detection in overhead imagery. *SPIE DSS, 11729,* 1172901.
5. A.J Pinar, A.J. Webb, J.L. Brown, **T.C. Havens**, B. Alvey, G.N. DeSouza, D.T. Anderson, and S.R. Price (Apr, 2021). Effects of perturbed depth sensors in autonomous ground vehicles. *SPIE DSS*, *11746,* 117461F.

Proposals on which equipment procured from this grant would be used

(*Recommended for funding*) SCC-CIVIC-FA Track B: Helping Rural Counties to Enhance Flooding and Coastal Disaster Resilience and Adaptation, NSF (PI: Thomas Oommen, Co-PIs: Guy Meadows, Timothy C. Havens, et al.)

(*Pending*) SAR GANs: Phase I, DTRA STTR Phase I (Prime: ARiA, MTU PI: Timothy C. Havens)

(*Pending*) STTR N21A-T010 UXO detection using nearfield acoustics, US Navy Phase 1 (Prime: Great Lakes Sound and Vibration, MTU PI: Andrew Barnard)

(*Declined*) Continuation: Defending the Nation's Digital Frontier: Cybersecurity Training for Tomorrow's Officers, Office of Naval Research (PI: Andrew Barnard, Co-PI: Timothy C. Havens, Laura Brown, Yu Cai)

(*Declined*) NRT-AI: STEM training to advance Socially Ethical and Ecologically Sustainable AI (SEES-AI), NSF (PI: Chelsea Schelly, Co-PIs: Timothy C. Havens et al.)

(*Declined*) Detection of underwater UXO using a multi-tiered approach integrating visual sonar and microbial biomarkers, SERDP (PI: Stephen Techtmann, Co-PIs: Guy Meadows, Timothy C. Havens)

(*Declined*) Development of a novel approach for rapid and real-time MSW analysis to produce homogeneous and flowable feedstock, US DOE (PI: Ezra Bar-Ziv, Co-PIs: Timothy C. Havens et al.)

(*Declined*) SBIR - Robotic Combat Vehicle (RCV) Sustainment, US Army STTR Phase I (Prime: GC Associates, MTU PI: Anthony Pinar, MTU Co-PI: Timothy C. Havens)

(*Declined*) NSF Convergence Accelerator Track E: Networked Autonomous Systems for Surface-Denied Observations, NSF (PI: Andrew Barnard, SP: Timothy C. Havens)

REPORT DOCUMENTATION PAGE

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5d. PROJECT NUMBER	**5e. TASK NUMBER**	**5f. WORK UNIT NUMBER**

6. AUTHOR(S)

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Final report for DURIP: Acoustic Sensing System and High-Throughput Computing for Environment and Threat Monitoring in Naval Environments Using Machine Learning. Includes description of equipment and equipment use. The equipment purchased with the funds from this DURIP grant supported 7 DoD contracts/grants, 3 industry contracts, and one NSF grant: a total of nearly $3.9 million in contracts and grants. Five publications have been published and 9 proposals have been submitted (5 DoD), to date.

15. SUBJECT TERMS

DURIP, acoustic sensing, high-throughput computing, machine learning

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