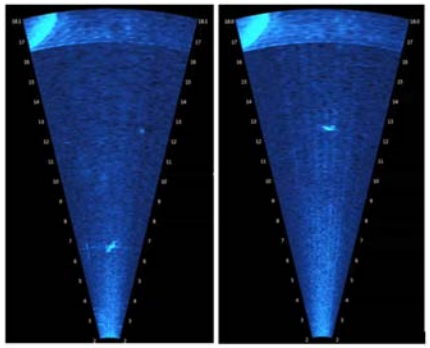
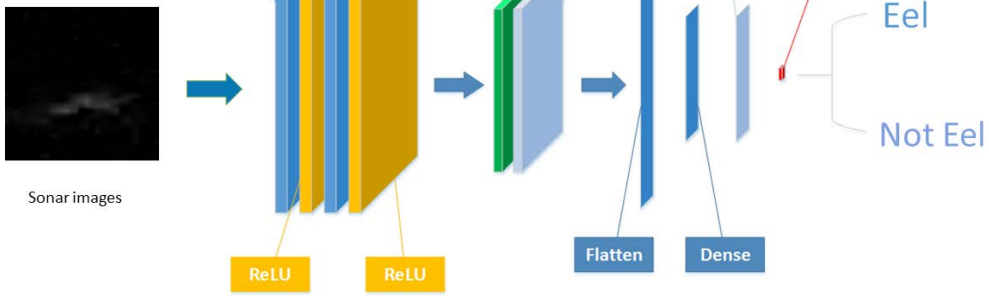




Deep Learning for Automated Identification of Eels in Sonar Data

DE-EE0008341

Hydropower Program

Wednesday, October 9, 2019

Paul T. Jacobson, Ph.D.

Electric Power Research Institute

Project Overview

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Project Summary

This project has the objectives of: (1) developing machine-based detection of American eel from ARIS sonar data; (2) demonstrating automated classification accuracy commensurate with human-supervised classification; (3) encapsulating the analysis tools in open-source, computer language packages; and (4) disseminating the results to the relevant technical community. The project uses wavelet filtering to enhance the video images and applies convolutional neural networks for deep learning and object classification. The results will facilitate R&D and monitoring of eel passage facilities at hydropower projects, thereby reducing costs and enhancing environmental performance.

Project Objective & Impact

Expected project result: proof of concept for automated detection, identification, and enumeration of adult American eels from sonar data and a set of open-source tools available to the public for further development and commercialization. Results will facilitate collection of site-specific information to improve the quality and cost-effectiveness of research for more effective American eel passage technologies and inform the deployment and operation of such technologies. The tools will also enhance the quality and reduce the cost of compliance monitoring.

Project Information

Project Principal Investigator(s)

Paul T. Jacobson
Electric Power Research Institute

WPTO Lead

Dana McCoskey

Project Partners/Subs

Daniel Deng, Xiaoqin Zang, Jason Hou, Robert Mueller, Tim Tianzhixi
Pacific Northwest National Laboratory

Project Duration

- September 1, 2018
- August 31, 2019

Alignment with the Program

Hydropower Program Strategic Priorities

Environmental R&D and Hydrologic Systems Science

Big-Data Access and Analysis

- Technology R&D for Low-Impact Hydropower Growth
- R&D to Support Modernization, Upgrades and Security for Existing Hydropower Fleet
- Understand, Enable, and Improve Hydropower's Contributions to Grid Reliability, Resilience, and Integration

Alignment with the Hydro Program

Environmental R&D and Hydrologic Systems Science

- Develop better monitoring technologies to evaluate environmental impacts
- Develop technologies and strategies that avoid, minimize, or mitigate ecological impacts
- Support development of metrics for better evaluating environmental sustainability for new hydropower developments
- Better identify opportunities and weigh potential trade-offs across multiple objectives at basin-scales

- This project reduces the cost and improves the timeliness as well as the consistency and objectivity of eel monitoring data, thereby improving hydropower operators' and regulators' ability to evaluate environmental impacts. The tools and techniques can be adapted to other species.
- By developing better monitoring techniques to evaluate environmental impacts, this technology development will improve R&D and management to avoid, minimize, or mitigate hydropower impacts on eels and other migratory species.
- By developing better monitoring techniques to evaluate environmental impacts, this technology development will improve R&D and management to avoid, minimize, or mitigate hydropower impacts on eels and other migratory species.
- Basin-scale evaluation of opportunities and trade-offs across multiple objectives requires cost-effective, consistent, and objective assessment of diadromous fish distribution, abundance, and behavior. This project advances industry and agency ability to conduct such evaluations.

Alignment with the Hydro Program

Big-Data Access and Analysis

- Help industry to manage large, disparate and dissimilar datasets relevant for performance, operations, costs, maintenance, permitting, and environmental mitigation
- Identify information-mechanisms that could increase coordination among permitting agencies

- Multi-beam sonar datasets are large. Identification of the acoustic targets of interest can be confounded by false targets (e.g., other species, debris). This project will help industry reduce sonar data storage requirements by allowing rapid analysis and reduction of data sets used for operations, permitting, and environmental mitigation.
- Rapid, consistent, and objective analysis of sonar data utilizing documented, open-source tools will facilitate cross-agency sharing of analytical results.

Project Budget

Total Project Budget – Award Information		
DOE	Cost-share	Total
$450K	$50K	$500K

FY17	FY18	FY19 (Q1 & Q2 Only)	Total Actual Costs FY17–FY19 Q1 & Q2 (October 2016 – March 2019)
Costed	Costed	Costed	Total
NA	NA	$37.4*	$37.4*

*** Excludes PNNL costs**

Management and Technical Approach

Key team members and contributions include:

- **Paul Jacobson, EPRI**, project management, eel biology and behavior, hydroacoustics, data management, stakeholder outreach
- **Daniel Deng, PNNL,** project management, data analytics
- **Jason Hou, Tim Yin, and Xiaoqin Yang, PNNL,** data analytics
- **Robert Mueller, PNNL,** laboratory experiments, hydroacoustics

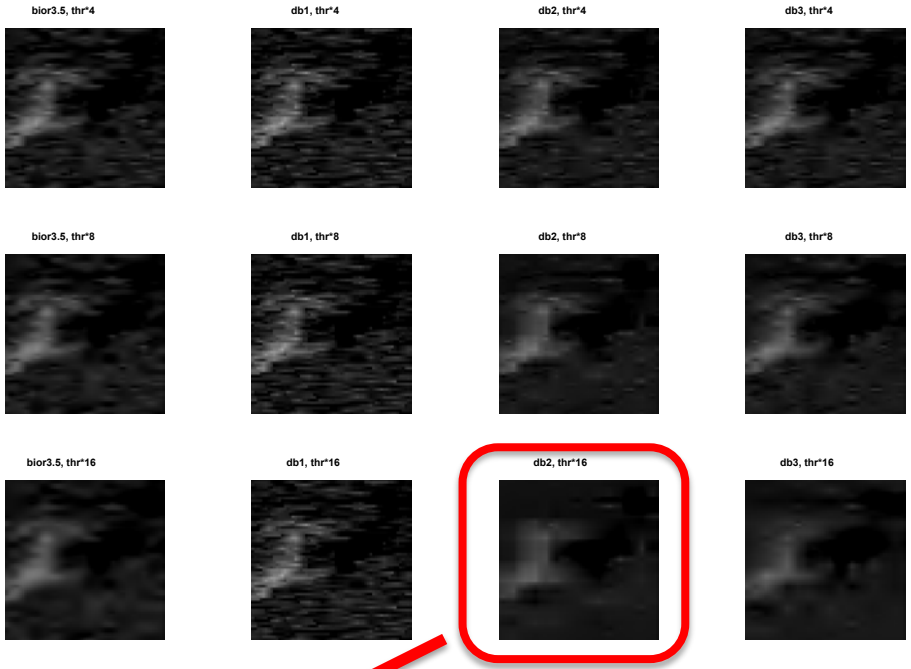
Progress was tracked through bi-weekly conference calls:

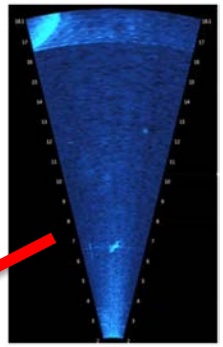
- Team members
- DOE WPTO technical representatives.

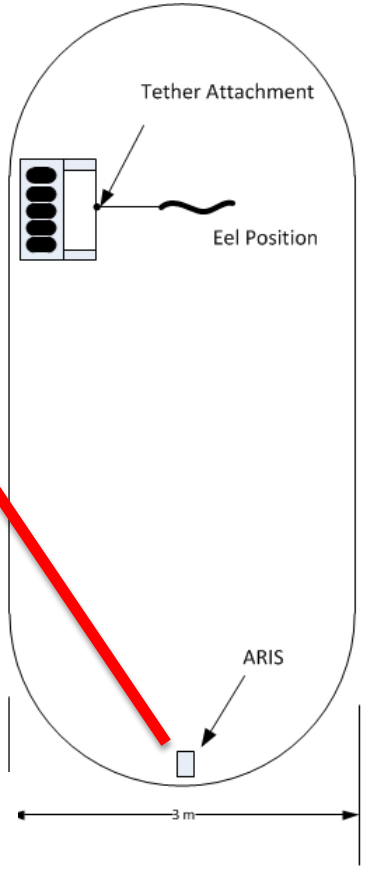
Schedule

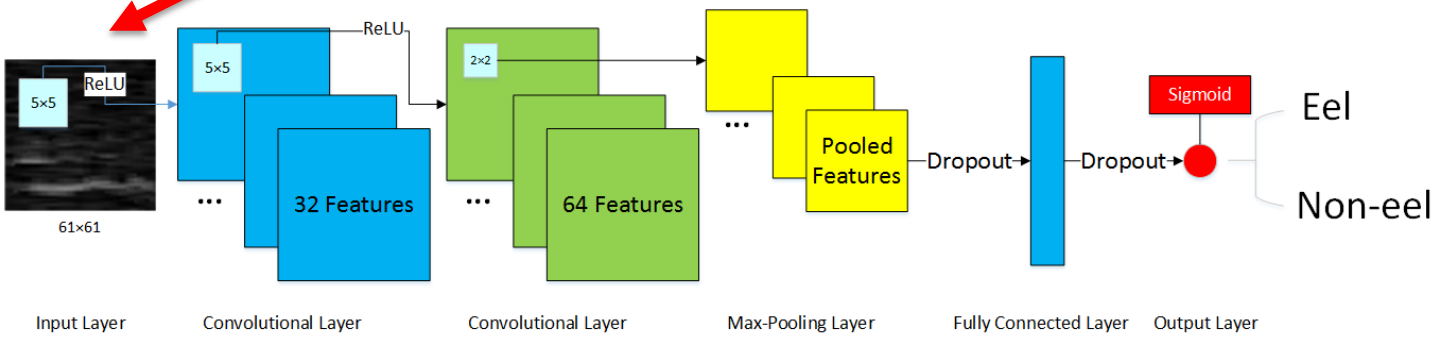
Task	Milestone Description	Quarter	Status
Application Space Discovery and Specification	Specified application space	1	Complete
Selection and Pre-Processing of Raw Field Data	Field data packaged for WT-CNN analysis	1	Complete
Meetings and Quarterly Reports	Kickoff meeting completed and documented	1	Complete
Laboratory Data Selection and Pre-Processing	Lab data packaged for WT-CNN analysis	2	Complete
Image Classification	Provisional software package for WT-CNN analysis of sonar data	3	Complete
Validation and Performance Evaluation	Validation and performance evaluation completed	4	Complete
Market Transformation	Phase 1 of the Market Transformation Plan completed	4	In Progress
Final Report	Final Report delivered to DOE	4	In Progress

Management and Technical Approach









End-User Engagement and Dissemination Strategy

Mid-project & Post-project Webinars

- Hardware providers
- Software providers
- Hydropower facility owners/operators
- Technical consultants
- Researchers
- Regulators

Publications/Presentations

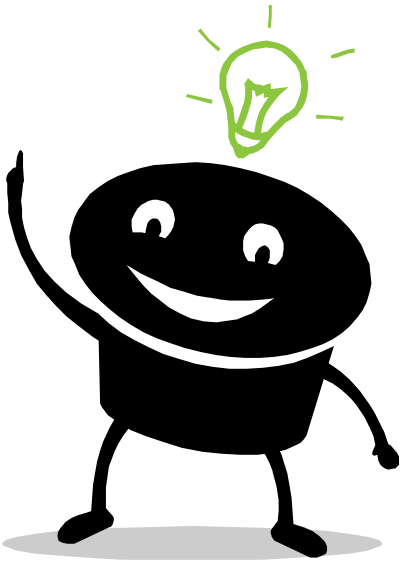
- Industry and technical conferences
- Peer-reviewed journals
- EPRI and DOE reports
- Software collaboration sites (e.g. GitHub)
- Lay publications
- Social media

Technical Accomplishments

Images classified as eels by CNN in each video clip (threshold %)	Eel accuracy	Stick/pipe accuracy
10%	94.3%	53.3%
20%	92.7%	60.7%
30%	92.7%	65.7%
40%	92.3%	69.3%
50%	92.3%	72.3%
60%	90.3%	73.3%
70%	87.0%	76.0%
80%	79.3%	79.7%
90%	73.7%	82.3%

Technical Accomplishments (Cont.)

- Laboratory data highly valuable for pre-training CNN algorithms
- High quality field data limiting for CNN algorithm training
- True positive rate commensurate with independent expert judgement
- False positive rate higher than independent expert judgement
- One (or more) papers accepted for publication in high impact technical journals



Thank you for your interest and Input