Where is Machine Learning Going in Marine Science?

Application of Machine Learning (ML) to Ecosystem Change Issues.

William L. Michaels and Cisco Werner
NOAA Artificial Intelligence (AI) Strategy

Expand the application of AI in every NOAA mission area in order to achieve transformational improvements in performance, skill, computational efficiency, and cost effectiveness.

NOAA AI Executive Committee:
RDML Timothy Gallaudet (NOAA Deputy USEC, AI Exec. Committee Lead),
Sid Boukabara (Co-chair, NESDIS), Bill Michaels (Co-chair, NMFS),
Charly Alexander (OMAO/USEC), Greg Dusek (NOS), Frank Indiviglio (OAR/OCIO), Ed Kearns (SO),
Vladimir Krasnopolsky (NWS), Mashkoor Malik (OAR/OER), John Mcdonough (OMAO), V. ‘Ram’ Ramaswamy (OAR), Neil Weston (NOS), Jeff Stewart (OAR), Hendrik Tolman (NWS), Cisco Werner (NMFS)
NOAA AI Strategy - Goals

- Transformational improvement in performance, skill, compute, and cost
- Transition to Operations
- Partnerships
- Workforce Proficiency
- RESEARCH
- ORGANIZATION

PICES Machine Learning Workshop, Victoria, B.C., Canada, October 18, 2019
NOAA Strategies – Integrated Approach

NOAA’s cross-functional mission priorities include integrated AI, UxS, and Omics technologies, and modernization of its data enterprise.

Cloud + Big Data
NOAA AI Strategy – Benefits

- Streamline Data Processing
- Data Fusion & Assimilation
- Predictive Forecasting
- Knowledge Discovery

Enhanced quality and timeliness of scientific products
How to assess that AI-based output (Satellite Analysis) is valid?

1. Assessing quality by comparing against independent analyses
2. Assessing Radiometric Fitting of Analysis
3. Assessing analysis spatial coherence
4. Assessing inter-parameters correlations

Google TensorFlow/KERAS

Tools used for MIIDAPS-AI

99.9% reduction in data processing
**Requirement:** Develop and implement advances in computer vision and artificial intelligence (AI) to automate processing and analysis of underwater still and video imagery for stock and habitat assessments.

**NOAA Fisheries Strategic Initiative WG members:**

**NOAA Fisheries:** William Michaels (Program Manager, OST), Ben Richards (Chair, PIFSC), Elizabeth Clark (NWFSC), George Cutter (SWFSC), Deborah Hart (NEFSC), Charles Thompson (SEFSC), Kresimir Williams (AFSC)

**External Experts:** Alexandra Branzan Albu (Univ. Victoria), Duane Edgington (MBARI), Anthony Hoogs (Kitware Inc.), David Kriegman (UCSD), Michael Piacentino (SRI International), Lakshman Presad (Los Alamos National Laboratory)
Video & Image Analytics for Marine Environments (VIAME)

Software to automate image processing, detection, classification, and rapid model generation using machine learning algorithms in a graph-like pipeline architecture.

VIAME Kitware Inc.: http://www.viametoolkit.org/
VIAME GitHub: https://github.com/Kitware/VIAME

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Presentation material does not constitute an endorsement by NOAA.
NOAA AFSC Bering Sea pollock survey

NOAA Alaska Fisheries Science Center utilizes VIAME to automate processing of video images from the Bering Sea pollock survey. Recent upgrades include improved precision with classification, stereo measurements, and 93% reduction in data processing (2.5 million images per survey, post-processing reduced from 3 months to 4 days).

Contact: Kresimir.Williams@noaa.gov
NOAA Northeast Fisheries Science Fisheries made progress with VIAME, including clustering-based web GUI for rapid annotation (50% reduction from manual annotations), updated object detection training API, and improved scallop detection model performance (99%). Approximately 2.5 million images are collected per survey, and VIAME has reduced post-processing by 98% (4 months to 4 days).

Contact: Deborah.Hart@noaa.gov
NOAA Southeast Fisheries Science Center is using VIAME for automated fish detection and classification during their annual video fish surveys in the Gulf of Mexico region.

VIAME recently used for developing image training datasets for red snapper and other commercially important fish species.

Contact: Charles.H.Thompson@noaa.gov
Automated Processing of Underwater Imagery

User friendly end-to-end pipeline using computer vision and deep learning for automated detection and classification.
Automated Processing of Underwater Imagery

Capability: Abundance estimates
NOAA SWFSC Aerial Pinniped Survey

NOAA Southeast Fisheries Science Center is using VIAME for automated fish detection and classification during their annual video fish surveys in the Gulf of Mexico region.

There is recent success in single detector pinniped models (training with 27 annotated images of 5,428 pinnipeds). Work continues to improve the GUI annotation module of VIAME, and need to improve the performance from a single detector model to a multi-class detector model.

Contact: Beth.Jaime@noaa.gov
NOAA PIFSC Marine Mammal Survey

NOAA Pacific Islands Fisheries Science Center’s Cetacean Research Program surveys marine mammals, and collected >170,000 of passive acoustic recordings from monitoring instruments throughout the Pacific Islands.

Google Artificial Intelligence (AI) to develop machine learning model to recognize and annotate humpback whale songs. Significant savings in processing with 90% in precision and recall. Presently expanding with for other whale species.

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NOAA PIFSC Coral Reef Surveys

NOAA Fisheries collaborated with scientists at the University of California San Diego (UCSD) to develop the CoralNet software as a web-based image classification system for coral reef habitats.

CoralNet has reduced PIFSC manual processing by at least 28% with potential cost savings for processing 525K coral benthic images from 11 person years ($1.4m) to 3 person years ($0.4m).

https://coralnet.ucsd.edu
CoralNet VIMEO channel:
https://vimeo.com/105839824

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Automated Processing of Underwater Imagery

The group is honored for working across NOAA line offices to develop the Video and Image Analytics for Marine Environment (VIAME) and CoralNet toolkit. This is the first automated image recognition software using advanced computer vision and machine learning technology for the marine environment. Scientific programs across NOAA have begun using the toolkit, resulting in immediate cost savings of 50 percent in processing time, with more precise, consistent, and timely scientific information to enhance knowledge discovery, and more confident decision-making for ocean stewardship.

This award, the highest honorary award given by the Department, is granted by the Secretary for distinguished performance characterized by extraordinary, notable, or prestigious contributions that impact the mission of the Department and/or one or more operating units.
NOAA Fisheries Data Modernization Initiative will be working with the NOAA Big Data Program to evaluate how to improve data accessibility for AI-ML analytics.

Federally verified and trusted third party commercial cloud providers have scalable platforms with quick data dissemination allowing greater usage of NOAA data.

NOAA Fisheries contact: Frank.Schwing@noaa.gov
NOAA Big Data Program: Ed.Kearns@noaa.gov
Participants provided inclusive and diverse perspectives from the government, academic and private sector for building partnerships to advance the ML applications for fisheries and marine science.

ML analytics are available, and will revolutionize our ability to process data more effectively with significant cost savings.

Improvements in the data management enterprise are required for enhanced data storage and accessibility, including annotated training datasets to improve ML classifiers.

Partnerships must be build on mutual understanding of value drivers.