

US Army Corps of Engineers Robotics and AI/ML for Critical Infrastructure Inspection

National Dam Safety Program Technical Seminar | 2024

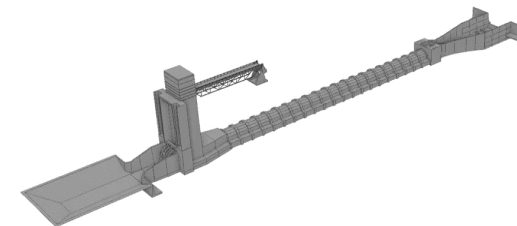
Anton Netchaev, PhD | Senior Research Computer Scientist
US Army Corps of Engineers



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Research Need

- The US Army Corps of Engineers (USACE) owns, operates, and maintains hundreds of dams across the United States
- Dam outlet works are susceptible to corrosion and fatigue that may compromise structural integrity
- Inspection of the outlet works, including hydraulic steel structures (HSS) present challenges due to safety and access restrictions
- Currently, this is largely manual process exposing personnel to hazards such as slips, trips, falls, low oxygen, and sometimes toxic gas



Dam outlet works flythrough



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Site Variation



- Solution needs to perform in a wide variety of conditions
 - Conduit size
 - Stilling basin design
 - Gate construction style and size
 - Conduit construction style
 - Entry obstacles in surrounding environment
 - Shore to water transition points
 - Flow conditions



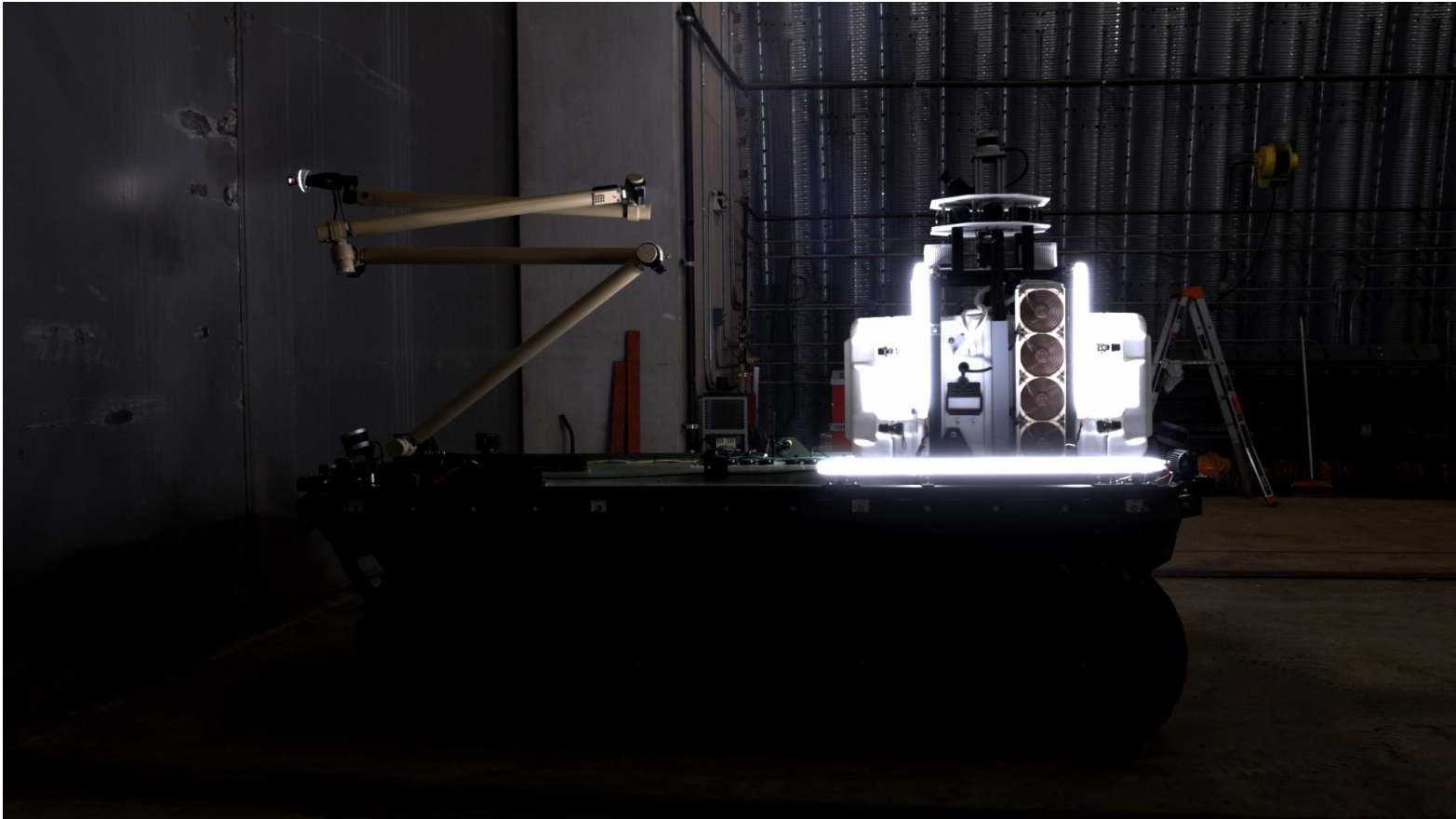
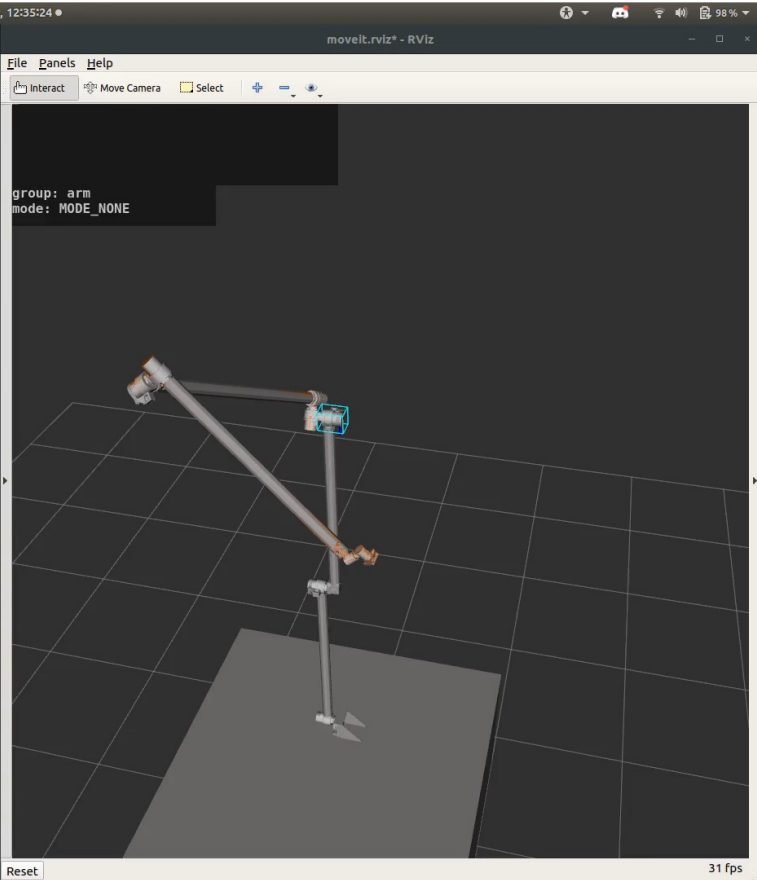
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DamBot™ Platform

- Sensor stack and computational capability built on top of Argo J8
 - Amphibious
 - Long battery life
 - High payload capacity
 - Department of Defense program of record platform base
 - 8-wheel drive for mobility

Robotic Arm

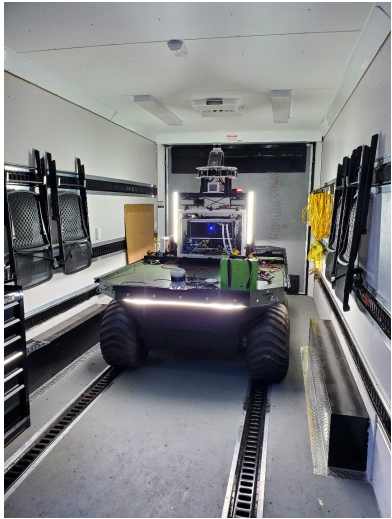


Robotic arm operation in modeling and real world environments



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Site Visits

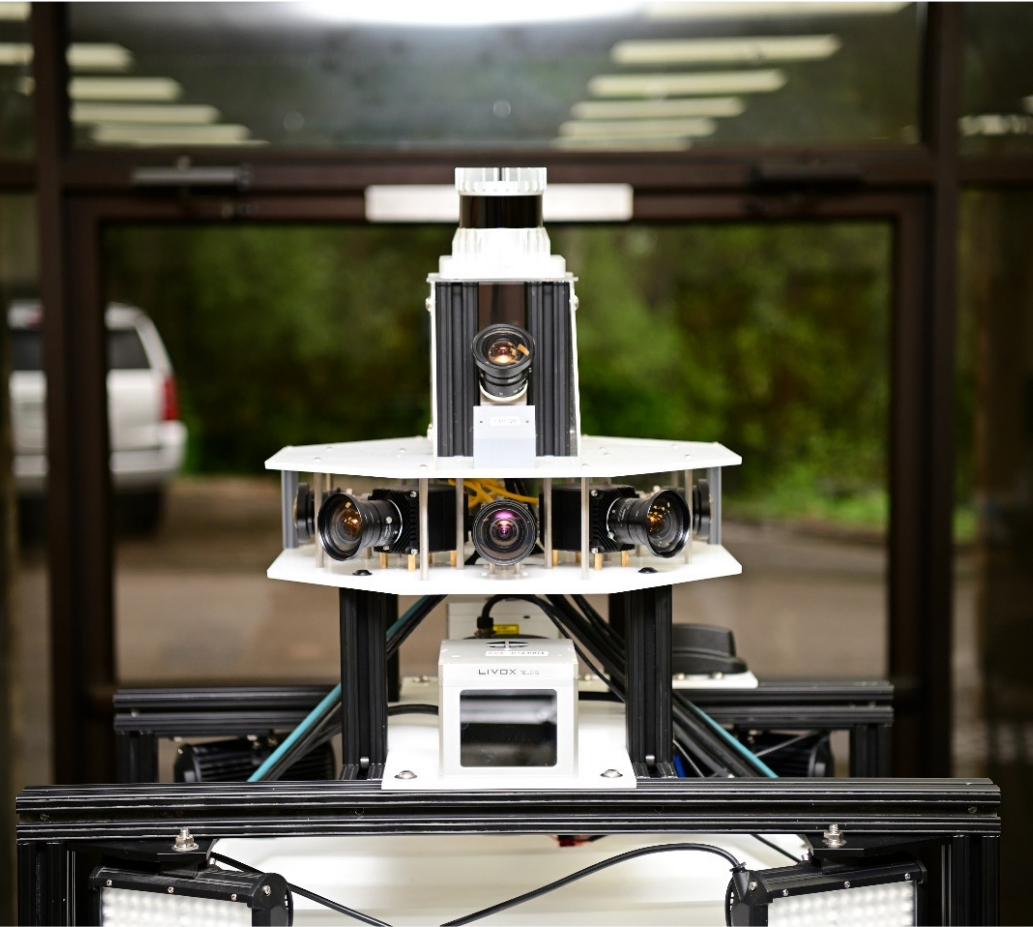


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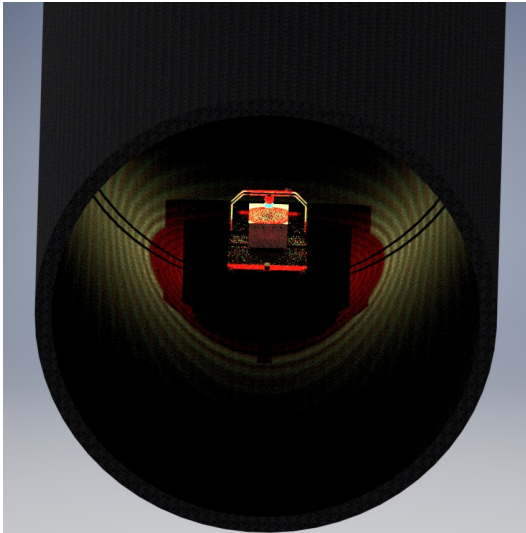
Dam conduit flythrough

National Dam Safety Program Technical Seminar

Computational Stack



ROS



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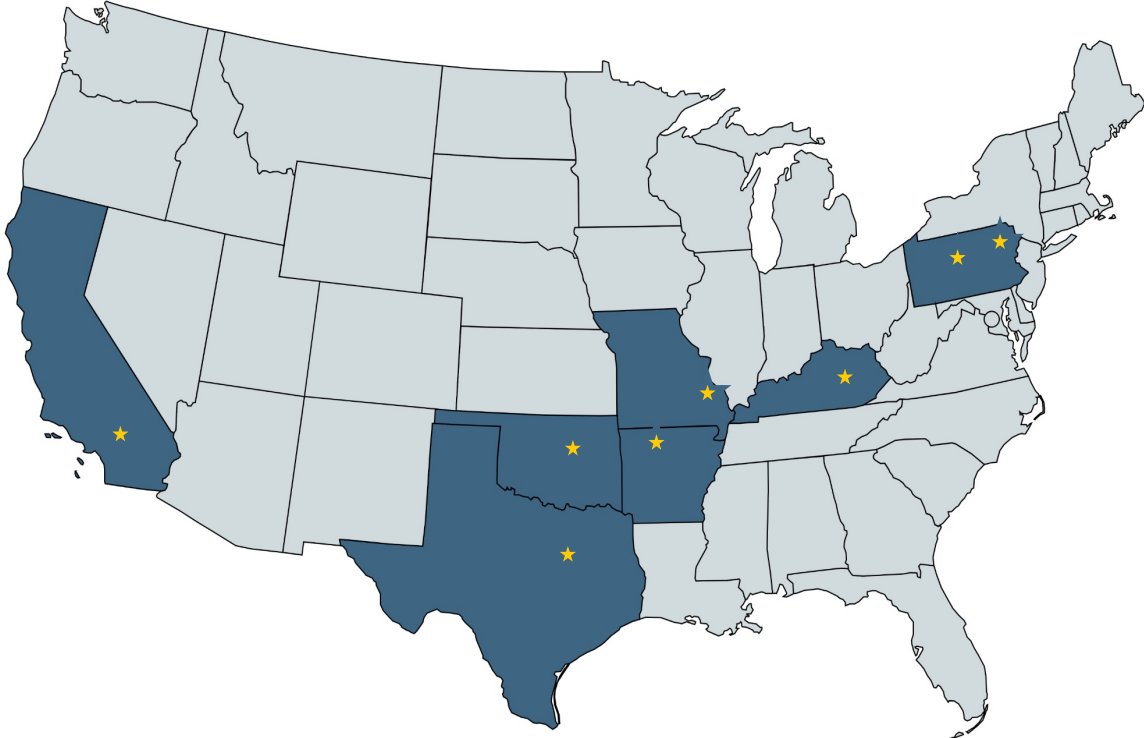
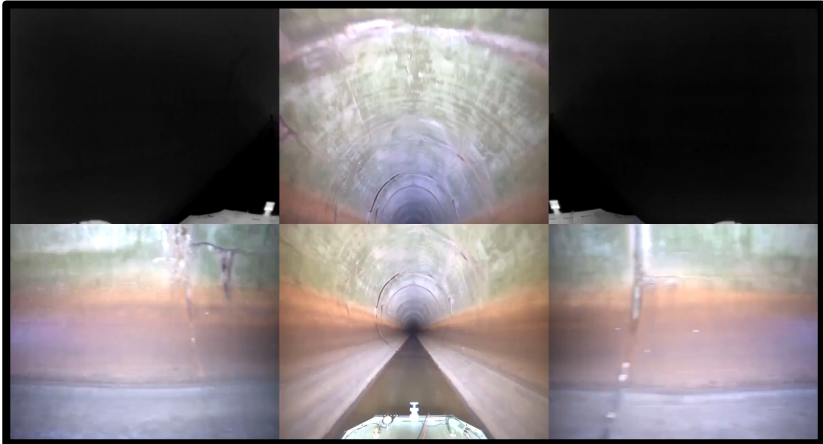
DamBot™ Mini



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Demonstration Sites

Camera data from DamBot



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Artificial Intelligence / Machine Learning Applications

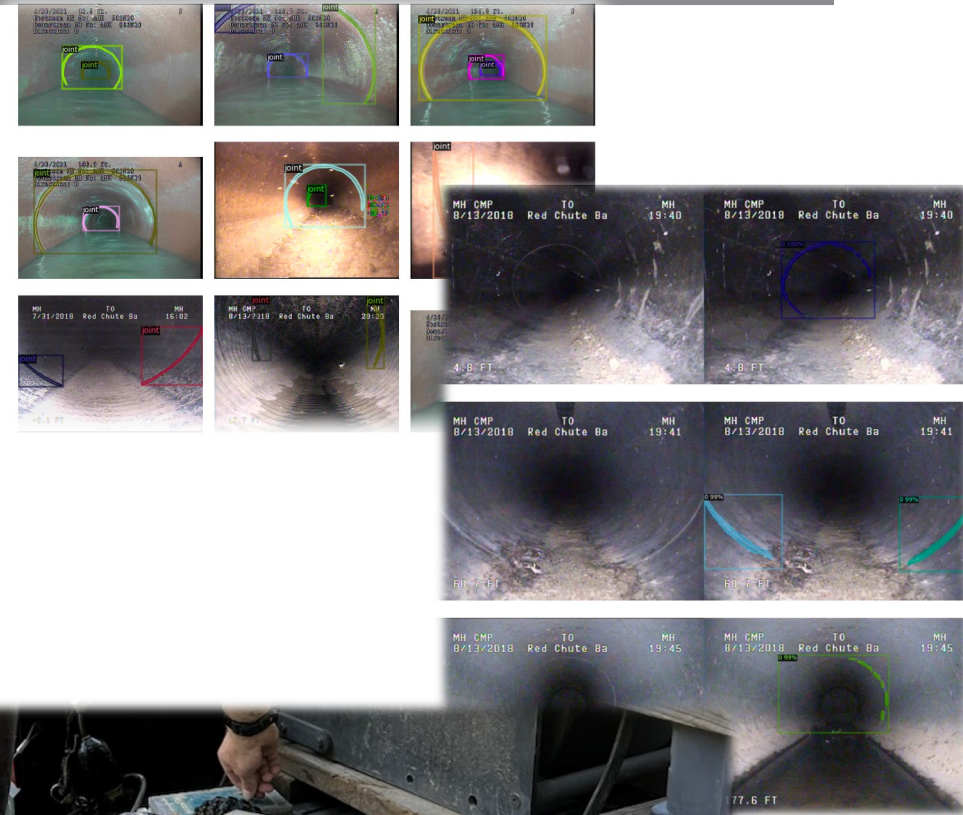
Research Needs

- ~14,000 miles of levees nationwide in USACE portfolio:
 - Federally operated and maintained (~30%)
 - Locally operated and maintained (~70%)
- Most common risk factor for very high and high risk levee systems is seepage through or under levees (~60% of systems):
 - Culvert through levee embankments or foundations are the most common contributor to seepage risk
 - 40% of levee systems with culverts have seepage risk due to culverts
- Other key risk factor is overtopping causing breach (~40% of systems likely to breach if overtopped):
 - Resilience depends on the presence of condition of armoring and vegetation of slope and adjacent ground surface
- Secondary contributors:
 - Encroachments, woody vegetation, sod cover, animal burrows
- Formal inspections every 5 years
 - Tools to improve efficiency, reliability, and ease of inspection will improve safety



Automating Conduit Inspections with AI/ML at USACE

- USACE has approximately 14,000 miles of levees Nationwide
- Most common risk factor for very high and high risk levee systems is seepage through or under levees (~60% of systems):
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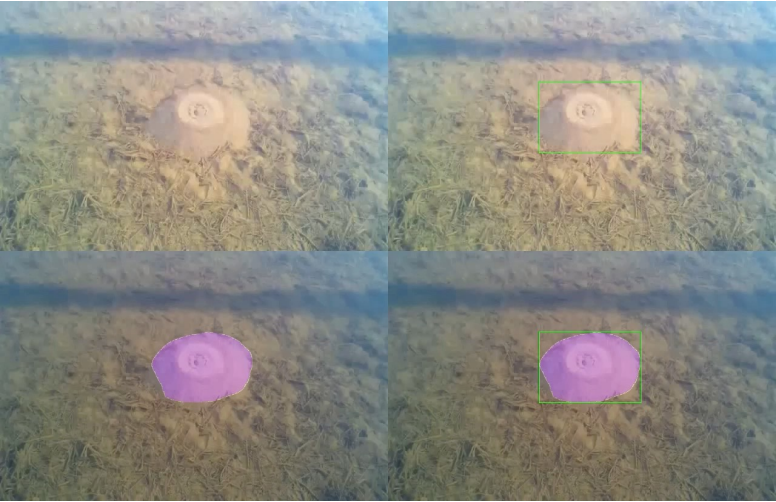


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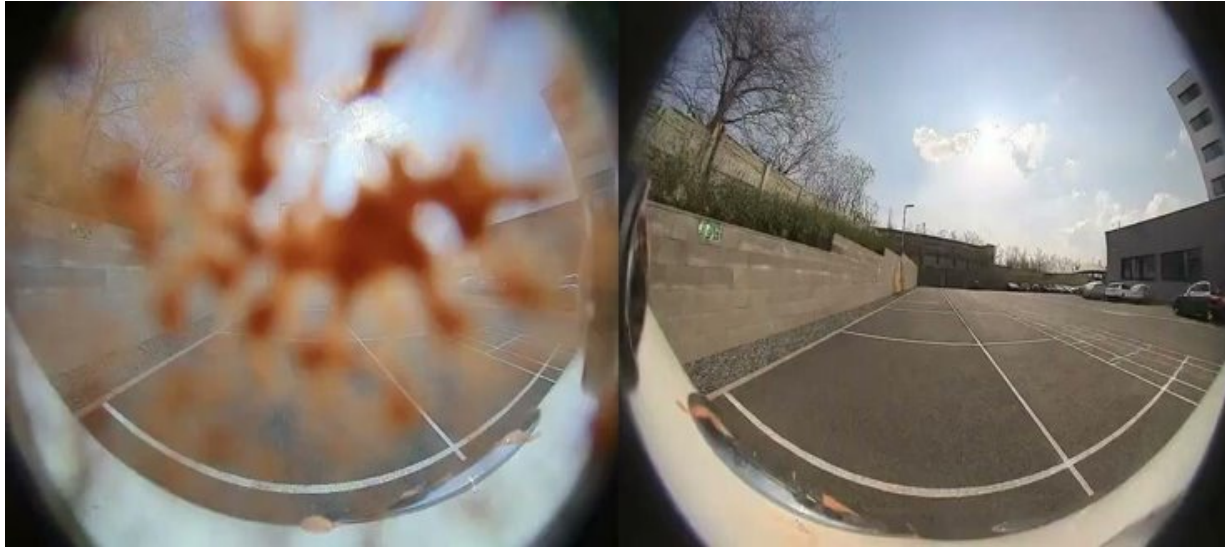
University Collaborations – University of New Orleans

- Leverage curated datasets to perform AI/ML detection of various defects in culverts as well as along levees
- USACE assisting with data collection, labeling, etc.
- Year 1 Publications:
 - Deep Learning Approach for Accurate Segmentation of Sand Boils in Levee Systems
 - Attention-Aware Wide Residual Model for Resource-Constrained Embedded Aerial Image Classification
 - Few-Shot Learning in Video and 3D Object Detection: A Survey

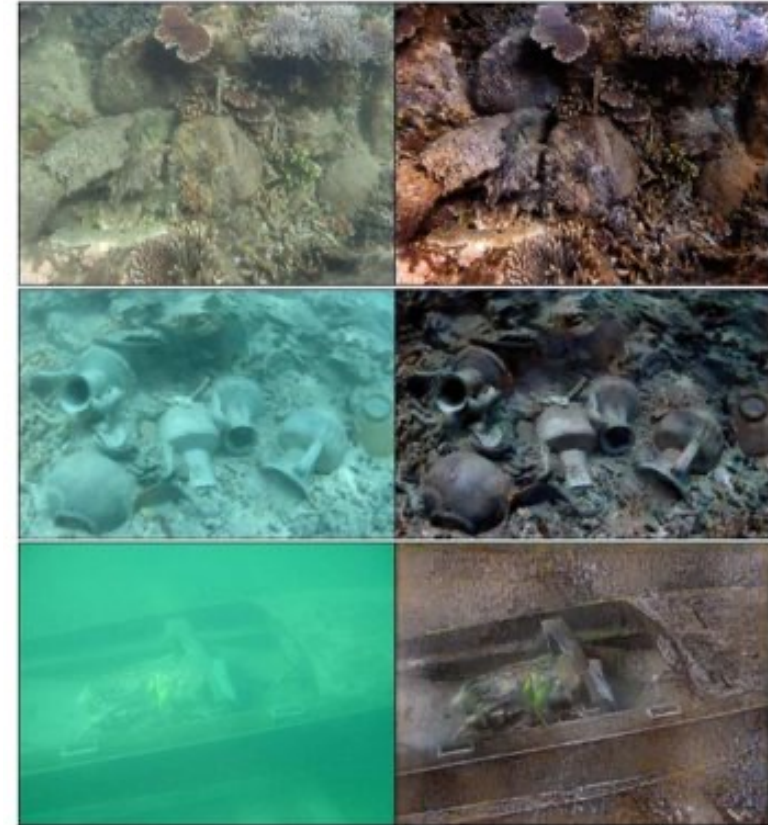


Fracture	Joint Problems	Root	Deformation	Crack	Loose gasket	Hole	Water Level Sag	Encrustation

University Collaboration – Texas A&M



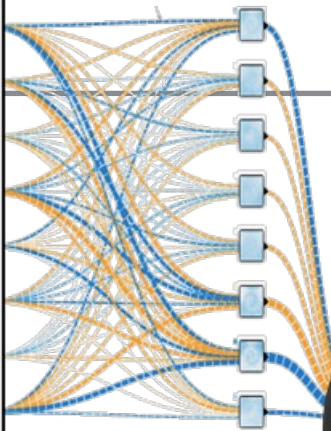
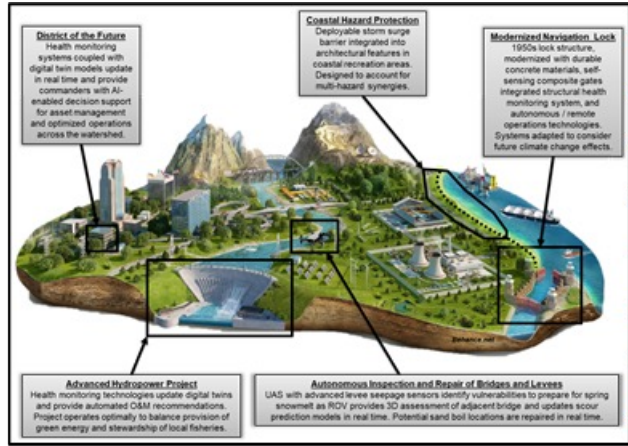
- Degraded Visual Environments image correction/restoration



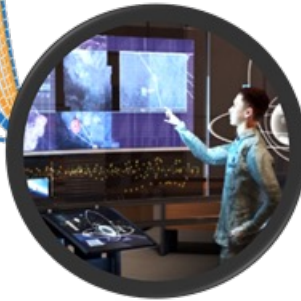
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NextGen Water Resources Infrastructure



Modernizing America's Infrastructure for the Future



Provides advanced materials, design, construction, health monitoring, risk quantification, and decision support tech. for improved resilience and reliability.

Strategic Drivers & Partners for Innovative Infrastructure

WRDA 2014, 2016, 2018 directed studies of innovative materials and advanced technologies for Civil Works infrastructure.

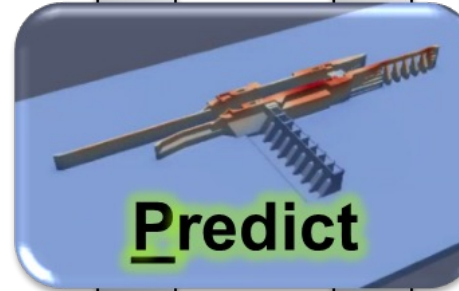


Government
Industry
Academia

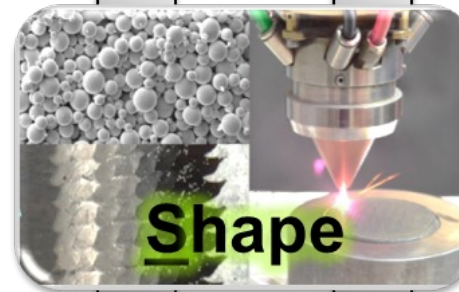
Materials Science Manufacturing Science Robotics Autonomy AI/ML Data Analytics HPC M&S



- Advanced quantitative NDE, SHM, and geophysical subsurface assessment tools
- Connect degradation to structural performance
- Complex aging mechanisms and synergies
- Agile and optimized risk-based analysis



- Aging infrastructure life extension modeling approaches
- Accurately predict future conditions through new models and integration of complex mechanisms
- AI/ML for structural health monitoring
- Multi-physics simulation of aging processes



- High-performance, multi-functional materials
- Design guided by predictive M&S capabilities
- Innovative manufacturing technologies, autonomy, robotics for repair and construction
- Innovative geotechnical design, construction and repair technologies and approaches

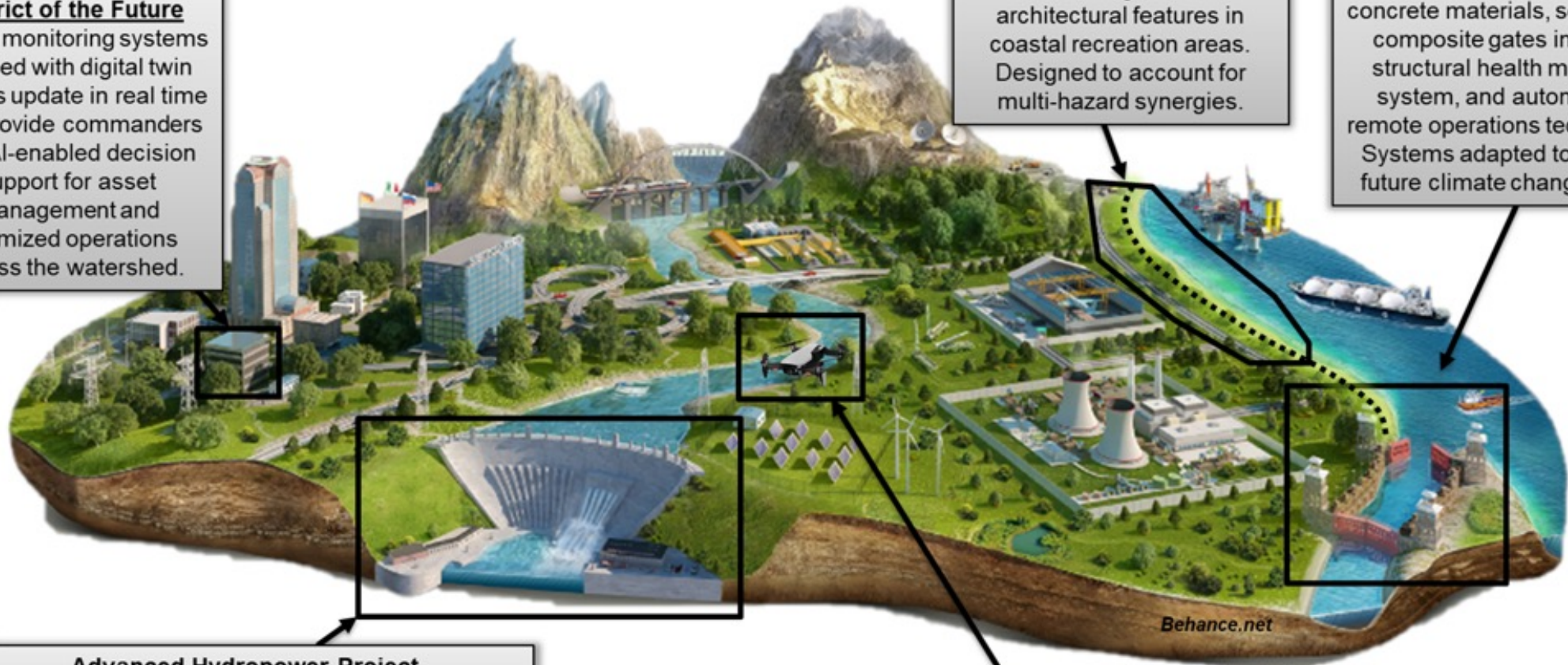
Cross-Cutting Technology Focus Areas

NGWRI Technology Vision

District of the Future
Health monitoring systems coupled with digital twin models update in real time and provide commanders with AI-enabled decision support for asset management and optimized operations across the watershed.

Coastal Hazard Protection
Deployable storm surge barrier integrated into architectural features in coastal recreation areas. Designed to account for multi-hazard synergies.

Modernized Navigation Lock
1950s lock structure, modernized with durable concrete materials, self-sensing composite gates integrated structural health monitoring system, and autonomous / remote operations technologies. Systems adapted to consider future climate change effects.



Advanced Hydropower Project
Health monitoring technologies update digital twins and provide automated O&M recommendations. Project operates optimally to balance provision of green energy and stewardship of local fisheries.

Autonomous Inspection and Repair of Bridges and Levees
UAS with advanced levee seepage sensors identify vulnerabilities to prepare for spring snowmelt as ROV provides 3D assessment of adjacent bridge and updates scour prediction models in real time. Potential sand boil locations are repaired in real time.



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Contact

Anton Netchaev, PhD
Senior Research Computer Scientist
Computational Science and Engineering Division
Information Technology Laboratory
Engineer Research and Development Center
Anton.Netchaev@erdc.dren.mil



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