INNOVATIVE ARTIFICIAL INTELLIGENCE (AI) FOR THE PROTECTION OF NATURAL AND BUILT ENVIRONMENTS

A pre-proposal prepared for ESF Discovery Challenge

Core group: Rafaat Hussein[1], PhD, PE; Margaret Bryant[2], PhD,
Rick Beal[3], PhD, Matt Williams[4], PhD
[1]ESF PBE, [2]ESF LSA, [3]Terra Science and Education, [4]Syracuse City School District

1.[5] a-INTRODUCTION -THE DISCOVERY OPPORTUNITY

The long term goal of this proposal is open-ended developments of AI technologies to protect the unprecedented fragility built and natural environments. For the short term, the proposal seeks supports to reach a milestone with what we already accomplished so far: an innovative proactive intervention approach using two AI-based modules to 1) accurately assess the integrity of built environment systems; and wastes and pollution in the natural environment; 2) prescribe corrective actions and monitor subsequent performance. The requested support is also necessary to develop and start the implementation of the roadmap for sustainability. So, why these two specific environments? First, report after report reinforces the prevailing critical state of disrepair of built environment. Governments around the world are grappling with the costly problems related to the repair of the built environment systems. In its 2017 report, as an example, the ASCE concluded that the overall average grade for the US national built environment is D+ and the cumulative needed investment for rehabilitation is $4,590 billion. Secondly, the health of the natural environment is another modern challenge globally. The EPA, USDA, USAID, UN have all agreed on the massive scale of the agriculture wastes' adverse effects on the natural environment. The literature suggests that with increased human prosperity, the agricultural sector is one of the major causes of the world's most pressing environmental problems including global warming, land degradation, air and water pollution, and the loss of biodiversity. It has emerged as one of the top two most significant contributors to the most serious environmental problems, at every scale from local to global. To elaborate, the EPA and World Bank suggested the need for accurate wastes statistics, knowing that there is more manure produced than human sewage in US (more than 5 tons for every citizen), 64% of it could not be absorbed by natural sinks such as soil, and with more than 50% of its storage areas leaking into streams used for drinking water. From a different perspective, the daily practices in the agricultural sector incubates and ascorbates serious disease outbreaks and epidemics that effect humans' health such as salmonellae, foot mouth, bovine spongiform encephalopathy, H1N1, and avian influenza. Perhaps the adverse impacts on the climate change is one of the most compelling arguments for this opportunity. In this regard, the sector is responsible for 51% of the global annual green gas emission, 9% of anthropogenic carbon dioxide, 37% of anthropogenic methane, 65% of anthropogenic nitrous oxide, 70% of anthropogenic ammonia, and untold amounts of solid and liquid hazardous wastes. These substances deoxygenate the surface and ground waters, deteriorate or destroy aquatic ecosystems, and pose threats to the biodiversity to name few examples. As gloomy as the status of the built and natural environments is, there is a hope. AI technologies are capable to intelligently probe the existing health of the ailing systems and act like humans to extend the service life span, reduce costs, and increase performance. To this end, the UN 2017 Summit identified AI technologies as crucial for protecting the environment and to conserve natural resources. There are many other calls to action[6] and this proposal is a reply.

Relevant expertise: [1]Computer simulations & environmental protection; [2]Environmental planning & conservation; [3&4]Educational & environmental pedagogy.

[5]The numbers of all headings match the criteria in ESF RFP Discovery Challenge.

[6]If this pre-proposal passes the first screening, a complete list of all references compiled for this project will be cited in the full proposal.

1. b-PROJECT DESCRIPTION

The AI field has gone through decades of developments by imitating human reasoning to solve prob1ems that normal1y require human attention. The AI has spawned subfields for practical applications such as knowledge-based systems which interchangeably referred to as AI-based tools and modules. These subfields transfer the expertise of problem-solving human experts into machine modules that utilize the same data and comes to the same conclusion as human experts, but much faster. If awarded, this project embraces this subfields' innovative approach to protect the built and natural environments against the impacts of threats, vulnerability, risks, wastes, and pollution. To this end, we developed two AI-based modules but they need further development for advanced human-machine interactions. The modules maintain two essential characteristics: modularity and reasoning. The modular component provides outputs which the human expert may consider as an advice to diagnosticate, interpret, predict, and instruct. The reasoning module is for human-machine interactions. These modules answer queries on the existence of problems; and their types and extent. First, for the built environment, our module integrates a number of AI-based tools for various applications including advanced materials like biobased, biodegradable; and renewable and green materials. Under the built environment, there is a sub-module for utility grids to probe the existence; location; and extent of faults; and the prediction of service life. This particular sub-module avoids the drawbacks of existing non-AI-based methods such as induced damages; disruptive societal services; and limited databases. To our knowledge, it is unmatched in its approach and avoiding the drawbacks of existing methodologies such as expensive data extractions. Its underlying principle is that dynamic signatures are the footprints of systems' integrity; i.e. health. Because the sought source of health' indicators and their locations are not known beforehand, a reverse engineering is infused in our AI process. A large sponsored project conducted at ESF concluded that human and the existing methodologies failed to accomplish what the AI-based approach did. Secondly, for the natural environment, this proposal uses an AI-based module to tackle the aforementioned pertinent environmental challenges via a proactive intervention-based approach for the assessment of wastes and pollution at their roots; i.e. before they spread. This is a logical approach to quantify the key environmental parameters that are very essential for every day operation including water, energy, beneficial utilization of resources, and determining the performance metrics. The conceptualization of this AI-based module encompasses extracting data for quantifying wastes and pollution at the source before entering the natural environment and resources; simulating various performance scenarios; and determining the trade-offs involved in the various performance scenarios. Its processing stages are identification of the existence of problems and their sources and types; quantification of severity; and identification of the adverse impacts. These stages route the AI process by addressing key questions such as: Are there hazards? What kind of hazard(s) is present? How severe are the hazards? In each stage, the hazards and pollution can be captured via data extraction and evaluation, and computational simulations. Once the existence, type, and extent of the problem(s) are captured, the following components start: wastes and pollution characterization; resources; and expert recommendation(s).

2, 3, 4, 5, 6, 7. EDUCATION, RESEARCH, REPUTATION, PARTNERS, AND ASSETS

I. Selected *benchmarks* that gauge the *significant leverage* this project brings to SUNY and ESF. In her first State of the University System address, Chancellor Kristina Johnson's stated "… competitor nations understand those who lead in artificial intelligence and machine learning will own the century" In her 2018 State of the University address, Chancellor Johnson emphasized innovation, sustainability, and partnerships. Also, ESF's *mission* states "to advance knowledge and

skills and to promote the leadership necessary for the stewardship of both the natural and designed environments." Our project echoes the Chancellor's *vision, agenda, and AI initiative*; rests on the built and natural environments, thus echoes ESF' mission; and will bring to SUNY and ESF for the first time a specific innovative direction at a large scale. This is a *platform* to reaffirm SUNY' and ESF' pioneering *reputation*; *broaden and deepen* the offerings of many of ESF' departments (e.g. ES, ERE, and LSA) via independent studies, electives, and interdisciplinary on AI; and arm the students with cutting edge technologies for competitive careers and leadership. The students will gain additional firsthand experience from the proposed seminars and hands-on workshops; and their engagement in the development, verification, and demos of the AI modules. Because the novelty of the proposed project, the data base of potential academic collaborators is relatively small. However, we expect an increasing interest in the applications of AI for the protection of the environments as we proposed. This means an increasing number of collaborators too.

II. Selected benchmarks about the project viability. We submitted a white paper on the early stage of the AI-based modules to the NSF and received promptly a reply from one of its directors stating "I think your proposal has some good ideas. We receive and review many proposals for research in various areas of health monitoring. Your proposal would *fit* into three or four program areas including mine." The first appearance of our built environment module received a contract from NYSEG but an agreement was unsuccessful because of terms. Later on, SUNY RF introduced to us a company to license the same module but an agreement was unsuccessful because of the unavailability of the needed the fund for a patent. The first appearance of the natural environment module was in a sponsored project by USAID and was used afterward for liaisons with one-on-one meetings four directors from NYS EPA and three from NYS DEC. Once heard about it, the director of Cornell' WMI travelled to Syracuse and had a meeting at ESF to learn about our module and explore future collaborations. In 2017, SUNY System became aware of our AI efforts and the rapport is very positive. We believe that we have established adequate database and positive rapports for future collaborators and partners from non-academic organizations.

III. Year 1 will be dedicated to the completion of our AI algorithms as previously described, deployment, and verification. These tasks will require the hiring of two postdoctoral candidates for two years each in addition to two MS graduate students. A dedicated office space on ESF campus will be required for these candidates. Year 2 will be dedicated to farther visibility building via outreach seminars and hands-on workshops using our modules. These events can be offered in ESF' lecture halls. We will extend invitations to the academic and non-academic AI stakeholders to participate and initiate a series of dialogues that cover a wide range of issues from the AI practices and challenges in the built and natural environments to the future opportunities, needs, and acceleration. Also, we will provide on-site demos at organizations such as NYS DEC, DA, EPA, DOT, HUD, BA, NYSERDA, various Onondaga county agencies such as environment, water, AGC, and DOT. Year 2 is pivotal to pave the way for future sponsored opportunities and partnerships, and will include closer interactions with SUNY, NSF, USAID, and EPA; establishing new contacts with additional key organizations to be selected through the proposed activities for years 1 and 2. Year 3 will be dedicated to documenting the efficacy of the AI-based modules, disseminating the achievements in papers and conference presentations, and to facilitate visibility efforts using a CD and a website. In year 3, we will continue our liaisons from year 2 in addition to seeking supports for sustainable future development after the end of the grant. Throughout the project' duration, the first member of the core group will be responsible for the overall management of the project; the second member will be responsible for the relevant scientific facets; and the 3rd & 4th members will be responsible for seminars and workshops.