CSSI Element: Elements: Data: Integrating Human and Machine for Post-Disaster Visual Data Analytics: A Modern Media-Oriented Approach

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VISER: Providing a Platform for Visual Data Analytics to Aid Infrastructure Assessment

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PROBLEM STATEMENT

Structures can be impacted by events (such as earthquakes or windstorms) over a short time, or over long time periods (for example aging infrastructure such as bridges). Visual data (such as images) collected from these affected structures contains valuable information that represents the status and state of the structure at the time images are collected. Images collected from structures represent valuable visual data that represents the status and state of the structure at the time images are collected. Quickly distilling insights from visual data is complicated by the large number and variety of images collected.

APPROACH AND GOALS

- **We have developed web-based applications**, intended to be used by researchers, structural engineers, and inspectors, **that focus on enhancing the experience of analyzing damage from images** collected during the inspection of infrastructure with different levels of damage likely caused by natural hazards.
- The goal of these applications is to reduce the time spent on organizing visual data to allow engineers to focus on understanding the damage in these structures.

APPLICATION FUNCTIONALITY

We have built a platform approach (VISER) to host

1. **Automated Reconnaissance Image Organizer** (ARIO – continued work from a prior NSF grant)
2. **Automated Bridge Image Reporting Tool** (ABIRT)

ARIO provides a user-friendly interface for users to

- register and log in
- create and generate reports
- upload inspection images to reports
- manage created reports from the user center page
- view and download public reports with classification results

ABIRT provides users the ability to

- upload bridge inspection images
- classify images with multistage labels
- switch different inspection years for viewing
- generate a comparison report across three years

COMPUTING INFRASTRUCTURE

We are investigating computing infrastructure approaches that seek to facilitate access to the capabilities provided by these applications.

IAC based approach for

- installing operating systems on bare metal systems or VMs
- securely extending Layer 2 networking to allow remote network booting (iPXE or UEFI)

Flexible Deployment - the application can be deployed on

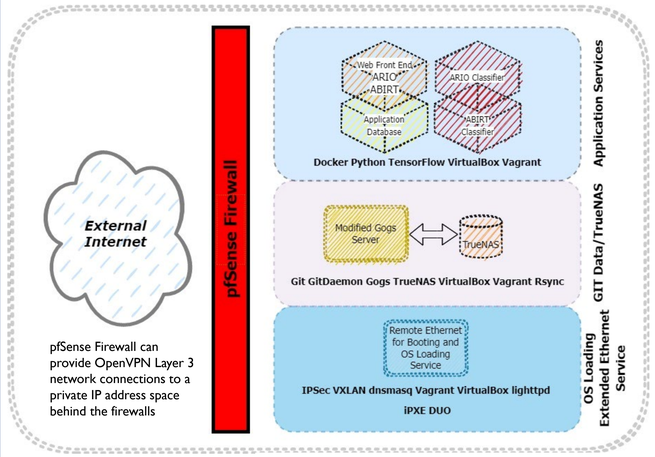
- central infrastructure
- portable computers (e.g., laptop) with Docker support
- Vagrant managed VirtualBox virtual machines

Online and Offline Use, based on different use cases, the application can be accessed through a web browser that is directed to

- centralized infrastructure when the network is available
- a local running VM or container instance of the application

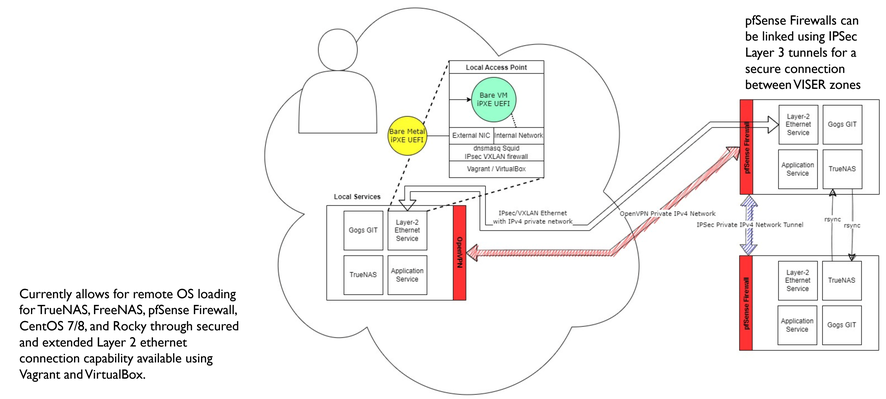
IAC INSIGHTS

The use of Infrastructure-as-Code (IAC) is complicated by several factors. Virtualization technologies used for IAC have multiple layers that need to be managed: networking, host platform, virtualization system, and guest OS support by the virtualization system (bare VMs vs. containers and/or Vagrant boxes). Another issue is the dependencies among the packages used and configurations for these packages as the software changes over time.



pfSense Firewall can provide OpenVPN Layer 3 network connections to a private IP address space behind the firewalls

TrueNAS servers provide common GitDaemon directories for the Gogs servers that allows users to publish their repositories across the collection of Gogs servers connected to the data node.



pfSense Firewalls can be linked using IPSec Layer 3 tunnels for a secure connection between VISER zones

Currently allows for remote OS loading for TrueNAS, FreeNAS, pfSense Firewall, CentOS 7/8, and Rocky through secured and extended Layer 2 ethernet connection capability available using Vagrant and VirtualBox.

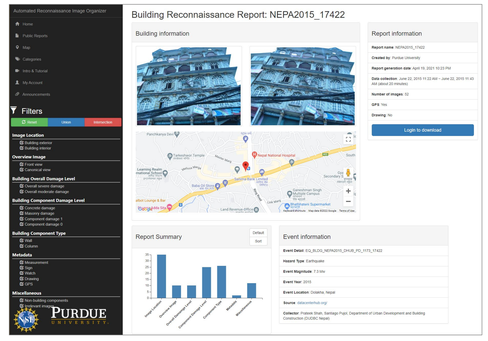
APPLICATION AND DATA SERVICES GOALS

- Provide interface for remote and local web access to applications for users or to data through Gogs or Git.
- ARIO and ABIRT applications are accessible through a web interface that connects through the VISER infrastructure to Docker containers. This allows the services to be provided through central infrastructure or local virtual infrastructure.
- A data service (currently a proof of concept under development) uses a modified Gogs web server. Modifications to Gogs allow users to "publish" their Git repo to a common file structure that is replicated (via rsync) across TrueNAS servers and is accessible (without the need for authentication) through a GitDaemon running on any Gogs node centrally or locally running on a VM on a local computer.
- User repositories on Gogs can be accessed via Git commands or through the Gogs web interface.

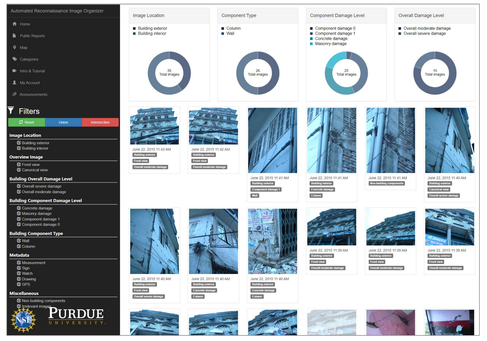
APPLICATIONS CONTAINED IN VISER: ARIO AND ABIRT

Inspectors can upload images collected during the inspection on the platform. The images are automatically tagged with category identifiers by using deep learning classifiers specially tailored for examining visual damages. A report is generated, and the user can review a collection of visual information based on information distilled from the uploaded images by the classifiers.
ABIRT, in addition, provides users the ability to compare images collected from different inspection years in the same report.

ARIO: Automated Reconnaissance Image Organizer

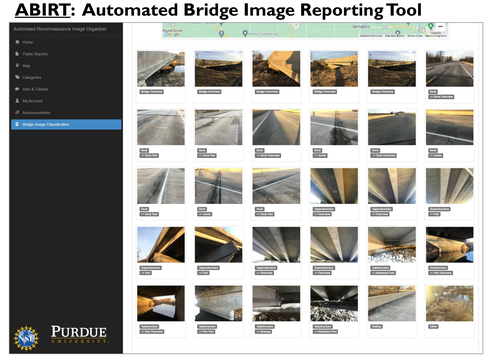


Categories included:
Building Overview, Concrete damage, Masonry Damage, Other.

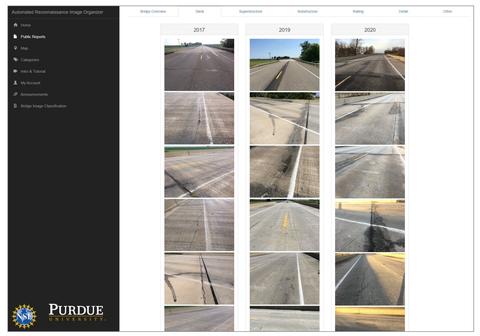


Classification results and statistical summary

ABIRT: Automated Bridge Image Reporting Tool



The categories relate to definitions in the bridge inspection manuals with categories that include Bridge Overview, Deck, Superstructure, Substructure, Railing, Detail, and Other.



Three years of inspections (Deck) comparison report

ARIO – STRUCTURES

The Automated Reconnaissance Image Organizer (ARIO -- based on extended work and software development funded from a prior NSF grant) organizes images for the analysis of earthquake damage in concrete buildings. A report is generated with a summary of the damage categories in the building and each image tagged with the categories according to the damage observed. The tool was developed using open databases from DatacenterHub.

ABIRT – BRIDGES

The Automated Bridge Image Reporting Tool (ABIRT) organizes bridge inspection images collected by bridge inspectors from routine inspections. The inspections are based on the requirements from the Federal Highway Administration (FHWA). A bridge inspection report can be generated with the bridge identification, location, and organized inspection images by the year they are taken. The ABIRT tool was developed by bridge routine inspection images collected by inspectors of INDOT and TXDOT.

PURDUE UNIVERSITY

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Liu, X., Dyke, S. J., Lenjani, A., Bilionis, I., Zhang, X., & Choi, J. (2022). Automated Image Localization to Support Rapid Building Reconnaissance in a Large-scale Area. *Computer-Aided Civil and Infrastructure Engineering*, 1– 23. https://doi.org/10.1111/mice.12828

IMAGES USED IN POSTER

Source images used for building report:
Prateek Shah, Santiago Pujol, Aishwarya Puranam, Lucas Laughery (2016), "2015 Nepal Earthquake Building Performance Database," https://datacenterhub.org/deedsdv/publications/view/537. DOI 10.7277/Z82F-0728. License: Creative Commons BY-SA 3.0. Image files available at https://datacenterhub.org/deedsdv/static_main/view/537/experiment_files_category/?filter=experiments.id|17203579
Source images used for bridge report: (used with permission)
BIAS (2018). Bentley® InspectTech™, INDOT.

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