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

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MOTIVATION

- Natural disasters can cause significant structural damage.
- Civil Engineers visit impacted regions immediately after an event and collect data to increase understanding of the response of structures to these events.
- Thousands of images are quickly collected.
- The complexity and tremendous scale of the collected visual data make it difficult to quickly and thoroughly categorize images based on content and location.
- We seek to address the problem:

How can researchers sort through and effectively distill understanding from a tremendous amount of visual data?

GOALS

- AI-based visual analytics image classifier and report generator for civil engineering.
- Automate the process of sorting through the thousands of images collected of structures after a natural disaster.
- Create a comprehensive cloud-based data analytics service based on data-as-a-service and applications-as-a-service.

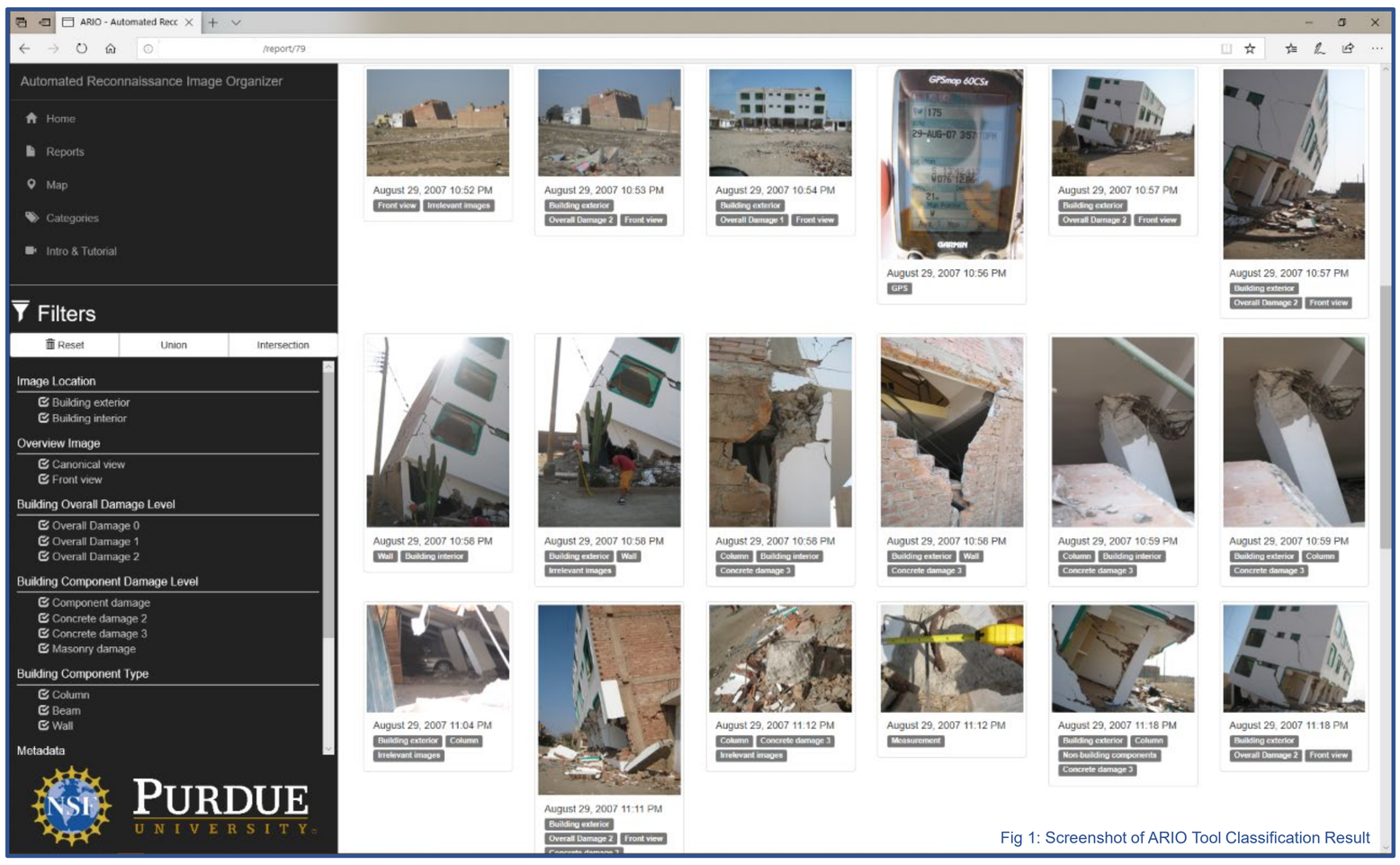

Fig 1: Screenshot of ARIO Tool Classification Result

CLOUD INFRASTRUCTURE

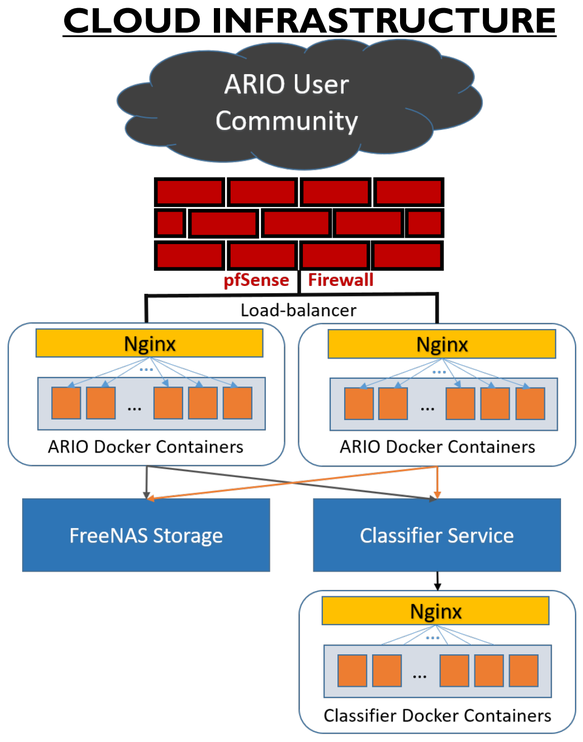

Fig 2: System Structure Illustration

Need a secure, distributed, shared cyberinfrastructure that can be used by a research collaboration to share data, applications, and a secure project portal for a research group as well as for the public.

GOALS

- Create secure distributed network communication zones and centrally managed data backbones.
- Create ephemeral computing service framework that provides data-as-a-service and applications-as-a-service.

STATUS

- Developed an approach to create secure layer 2 (Ethernet) and layer 3 (IPv4) network zones between a central server and remote virtual machines built on the use of Vagrant and Infrastructure as Code (IAC) techniques.
- Migrated the ARIO report generator to run within Docker containers and created a Docker repository to store and distribute ARIO containers.
- Set up a FreeNAS data storage server that is linked to the Docker containers to store and share data among ARIO users. The FreeNAS server is the first stage of the data backbone for the system.
- Set up an MS-SQL database Docker container with backups for the ARIO report data.

PLANS

- Build on secure network infrastructure and IAC approaches to create distributed secure data backbone.
- Use the distributed secure data backbone to create a computing service framework built on a collaborative network of securely linked lab-scale private cloud systems.

APPLICATIONS-AS-A-SERVICE

Provide access to applications built on visual data that are tailored for civil engineering uses.

GOALS

- Provide service to rapidly classify and analyze large collections of images.
- Provide similarity-based visual search capability.
- Provide an application that can leverage existing pre-disaster imaging (i.e. Google Street view) for pre-event context.

STATUS

- Implemented taxonomy and classification on image upload in ARIO.
- Implemented filter capability to allow users to select classification categories to display in ARIO.

PLANS

- Hold workshops to gather user requirements and disseminate services to the community.
- Implement the similarity search capability.

DATA-AS-A-SERVICE

Facilitate access to a large volume of images for a distributed research collaboration and community.

GOALS

- Provide a "ground truth" collection of images for classification.
- Develop an image classification taxonomy appropriate for the civil engineering domain and the types of images collected after an event.
- Develop an annotation tool to allow the community to add notes to images.

STATUS

- Developed large set of classified "ground truth" images and taxonomy implemented in ARIO.
- Images and database are stored in FreeNAS and Docker containers to share among running Docker instances running ARIO tool.

PLANS

- Build out data backbone on secure network infrastructure.

Science-oriented Visual Data Taxonomy

- Goal: use a taxonomy to organize images and for category-based search.
- We added new categories for classification taxonomy to designate building components and damage level when information is available.
- Taxonomy categories used to train neural network to automatically tag images and train multi-label classifiers for ARIO.
- We updated the ARIO by adding an image filter function along with video and text instructions and added reports for many buildings.
- Now have over 140,000 tagged images from past reconnaissance missions.
- With 75% train and 25% test, over 50 epochs, found sample weighted precision and recall score of 90% and 79%.

Search Capability Based on Visual Similarity Between Buildings

- Goal: Simplify the process of report generation based on taxonomy categories, and damage types and levels.
- Uploaded images are automatically classified by neural network into categories as a part of uploading process.
- Users can filter reports based on classification categories. Report generator allows users to select categories to display.
- Developing similarity search capability based on building overview images and a Siamese convolutional neural network (S-CNN) with the goal of allowing users to search for the same of similar types of buildings.

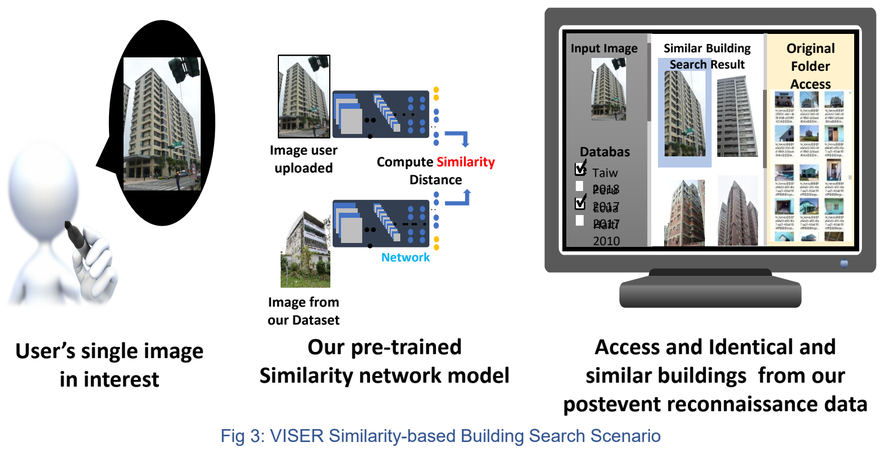

Fig 3: VISER Similarity-based Building Search Scenario

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