CAM$^2$ - Continuous Analysis of Many CAMeras

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The Problem
Currently there is no common system that allows researchers to access the images from many Internet connected public cameras and analyze them in real time to extract useful information. The goal of CAM$^2$ is to create a system that brings the data from these Internet connected cameras and a way to perform large-scale analysis together so that people can perform powerful data analysis in an easy way without having to have great expertise.

Possible Applications
Possible uses of the system include:
• Traffic analysis to improve congestion or detect accidents
• Weather observation to increase the accuracy of existing weather models
• Track environmental trends (rising sea levels, shorter days, etc.)

The Infrastructure
The system includes:
1. A large number of publicly available cameras and their properties
2. A website that lets users interact with the system by selecting cameras to analyze, uploading image analysis programs, executing analysis submissions, and downloading results
3. A resource manager (system) that allocates and manages the resources needed for executing the analysis programs
4. Amazon cloud computing instances to execute the analysis programs

Cloud-Based Distributed System Architecture
Above is a diagram of the interactions between the user and the different aspects of the system. The user will interact with the website by selecting cameras and uploading image analysis programs that communicate with the system through an API. A manager allocates and manages all the resources needed to execute the analysis programs on the cloud computing instances. A cloud-based system was used because it offered good scalability options. If there are a lot of submissions being executed, we can allocate more cloud instances. When there are few submissions, we can stop the instances not in use.

System Overview
• Users will interact with the system through the easy-to-use website application at cam2.ecn.purdue.edu
• Current number of cameras in our system is 38,052 from all over the world (more are being added)
• Filter cameras by country, city, and state or by time zone
• Users specify duration of analysis, number of cameras, and frame rate
• Users can select from over a dozen provided sample analysis programs or create and upload their own
• Sample analysis programs include motion detection, color detection, object counting, sunrise/sunset detection, and more
• Uses the image processing library OpenCV 3.0 to provide users with powerful image processing tools
• Easy-to-learn API for users’ programs to interact with system
• Results of the analysis submission are available via download at any time

Image Processing API
The image processing API is designed to take image processing programs and easily convert them to be compatible with CAM$^2$. Users just write a processing algorithm using OpenCV functions and plug it into the API.

Object Tracking/Counting
This sample analysis program analyzes frames from a camera to detect moving objects and track/count them.

Algorithm Steps
1. Perform background subtraction to get the foreground
2. Remove noise from foreground
3. Use contours to find objects
4. Enclose objects in bounding rectangles

Conclusion
CAM$^2$ provides an easy way to perform large-scale analysis on camera data from all over the world in real time. All users have to do is select the cameras to analyze, specify a few settings like duration, choose from a selection of provided analysis programs or upload their own, and press the execute submission button. CAM$^2$ does all the work retrieving images from the cameras and executing the analysis programs on them. People can now register on the CAM$^2$ website, cam2.ecn.purdue.edu, to begin analyzing camera data.

Future Development
• Improve camera selection function to include search by camera type (traffic, landscape, indoor/outdoor)
• Scale up from 40,000 cameras to hundreds of thousands of cameras
• Provide more sample analysis programs for users

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References