Wildfire Detection Using a CPS

Background

- Fire Departments including CALFIRE used to have look-out towers in forests
- Look-out towers are costly to maintain
- CALFIRE does not have any active look-out towers
- People use cell phones to report wildfires
    - => May cause delay and
   - => location estimation problems

Wildfire Detection using a CPS

- Our project aims to empower ordinary citizens to take charge in collecting real time environmental data that can be used to serve a common interest.

- Volunteers can be part of a CPS. They can use their smart phones to take picture of a wildfire and upload it to a server.

- Each volunteer will be a node of the CPS

- Quick detection and location accuracy and a small number of nodes are two fundamental but contradicting goals of the envisioned wildfire detection CPS.

Fire Department (server) view of the coverage area

- The server is responsible for collecting and processing information in the defined coverage area.

- The coverage area will be divided into coverage grids

- The server can direct nodes and/or supernodes to empty grid locations.
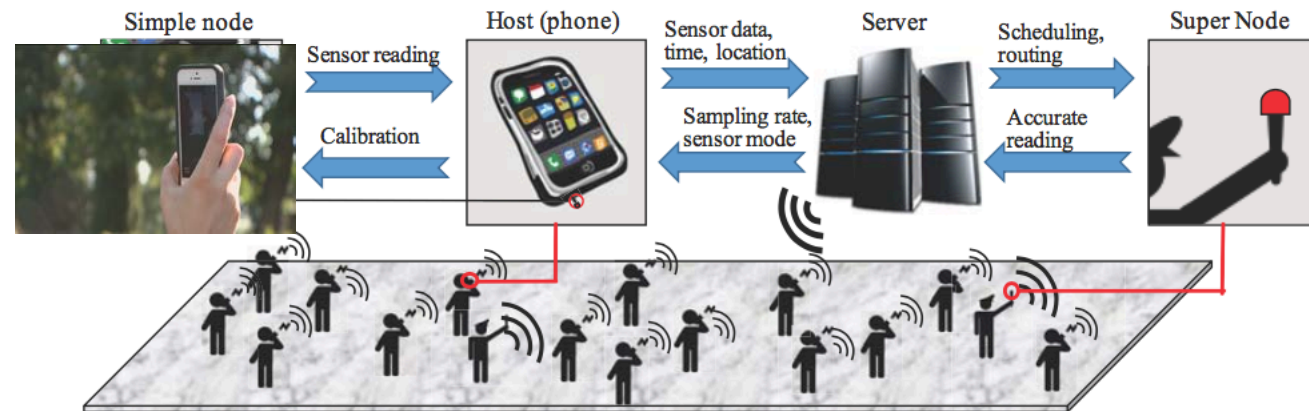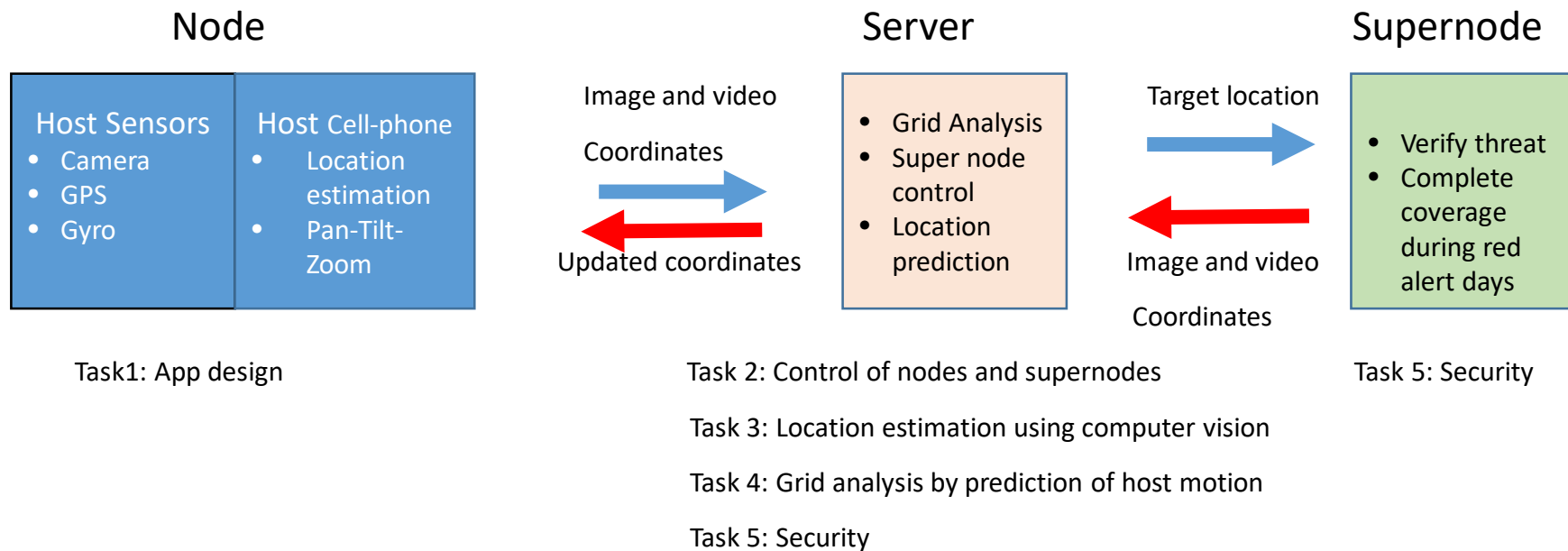
- I will

- Update

- the fig

Figure 1: Overview of the proposed threat detection CPS including nodes, supernodes, and the server

Proposed Wildfire Detection CPS components, interactions, and tasks

- "Nodes" use camera, GPS Coordinates, and Pan-Tilt-Zoom (PTZ) info to report a wildfire

Node

Host Sensors	Host Cell-phone
• Camera	• Location estimation
• GPS	
• Gyro	• Pan-Tilt-Zoom

Task1: App design

Image and video

Coordinates

Updated coordinates

Server

- Grid Analysis
- Super node control
- Location prediction

Task 2: Control of nodes and supernodes

Task 3: Location estimation using computer vision

Task 4: Grid analysis by prediction of host motion

Task 5: Security

Target location

Image and video

Coordinates

Supernode

- Verify threat
- Complete coverage during red alert days

Task 5: Security

Proposed wildfire detection CPS components, interactions and tasks

Grid Structure of the CPS

- A *level-0 grid* has no node and no coverage. To enhance coverage, the server will request the nodes in the surrounding grids to go to the level-0 grid. If no such node exists, it is necessary to send a supernode to the grid to check its status.

- A *level-1 grid* has one or two nodes and hence limited coverage since the server may not accurately determine the location of the wildfire. It is necessary to have two or more nodes to accurately estimate the location of the wildfire using computer vision or triangulation.

- A *level-2 grid* has three or more nodes which is sufficient to estimate the location of a wildfire accurately.

Server view of the coverage area, grid partition, and grid classification
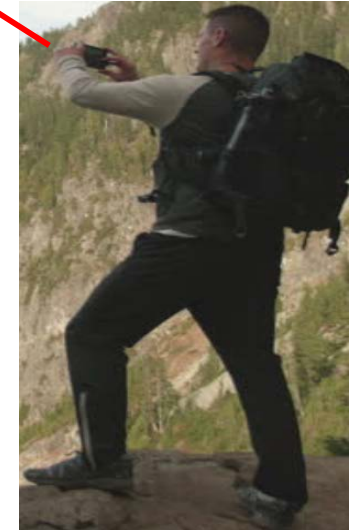

Coverage area   Division into grids   Grid classification
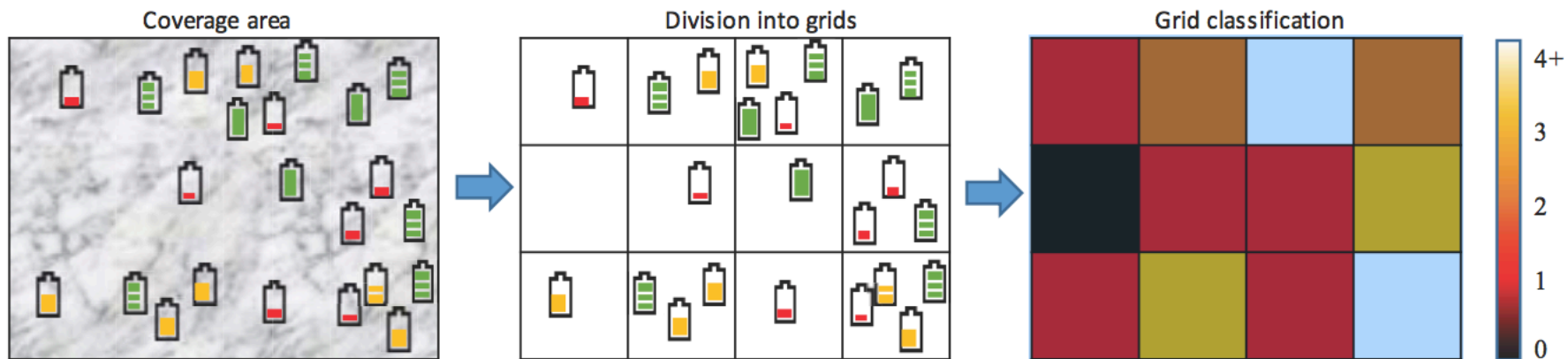
Server will request the nodes in the surrounding grids to go to the level-0 grid.
In the above example, a "supernode" should go to level-0 grid (dark).

Wildfire Detection:

Node 1

Node 2:

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- **Node(s) take pictures of the wildfire and upload them to the server.**
- **Cell-phones of the nodes also upload their GPS coordinates and pan-tilt-zoom information of the cameras**
- **The server estimates the location of the wildfire using triangulation, if there are two or more nodes**
- **If there is a single node, the server matches the image with the images in its database or satellite images of the region**

Computer Vision Problem: Estimate the exact location of the wildfire from different images of nodes
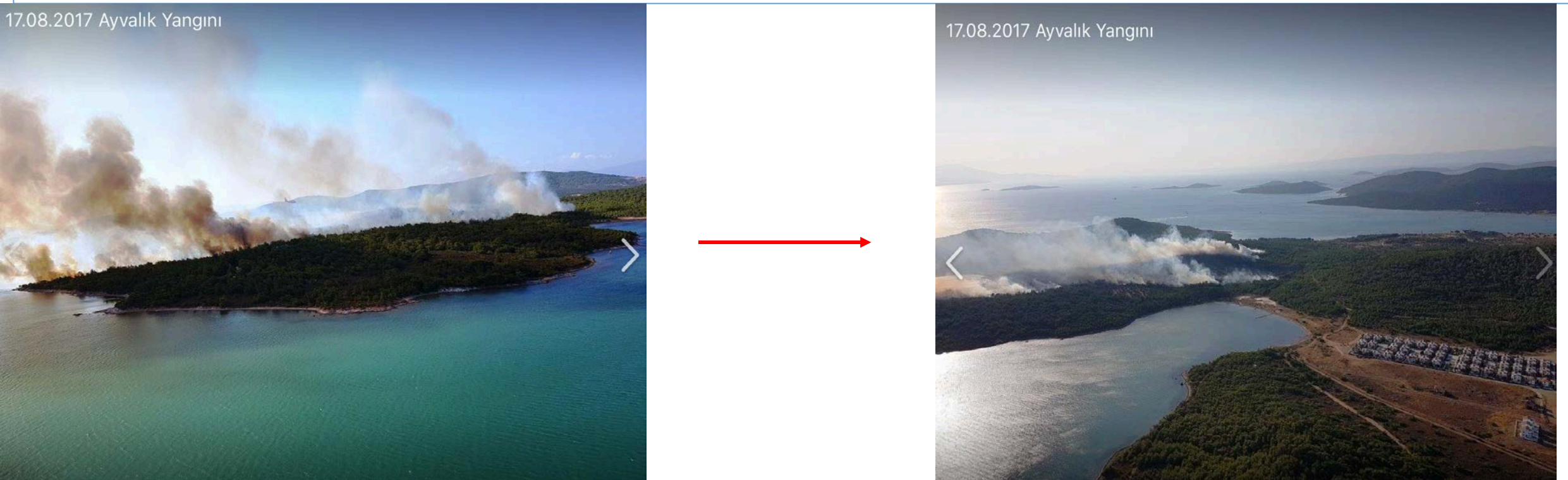
- The wildfire is behind the hill!
- Match images sent by nodes to satellite images of the region or image database of the region to determine the exact location
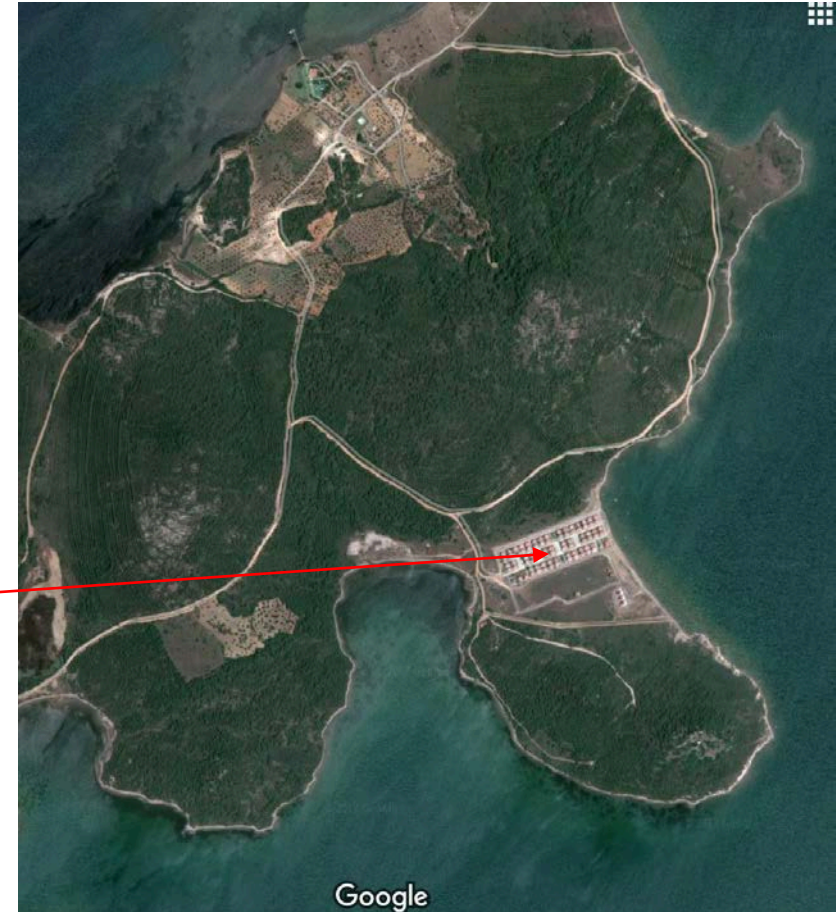
Match the two images to determine the location

Use Scale Invariant Feature Transform (SIFT) or Deep ConvNets to match images

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Image taken by a fireman

Satellite Image of the wildfire region

Acknowledgement