Remote Sensing for Forest Fire Prediction and Detection

La Télédétection pour la Prédiction et la Détection des Feux de Forêt

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Electrical & Computer Engineering

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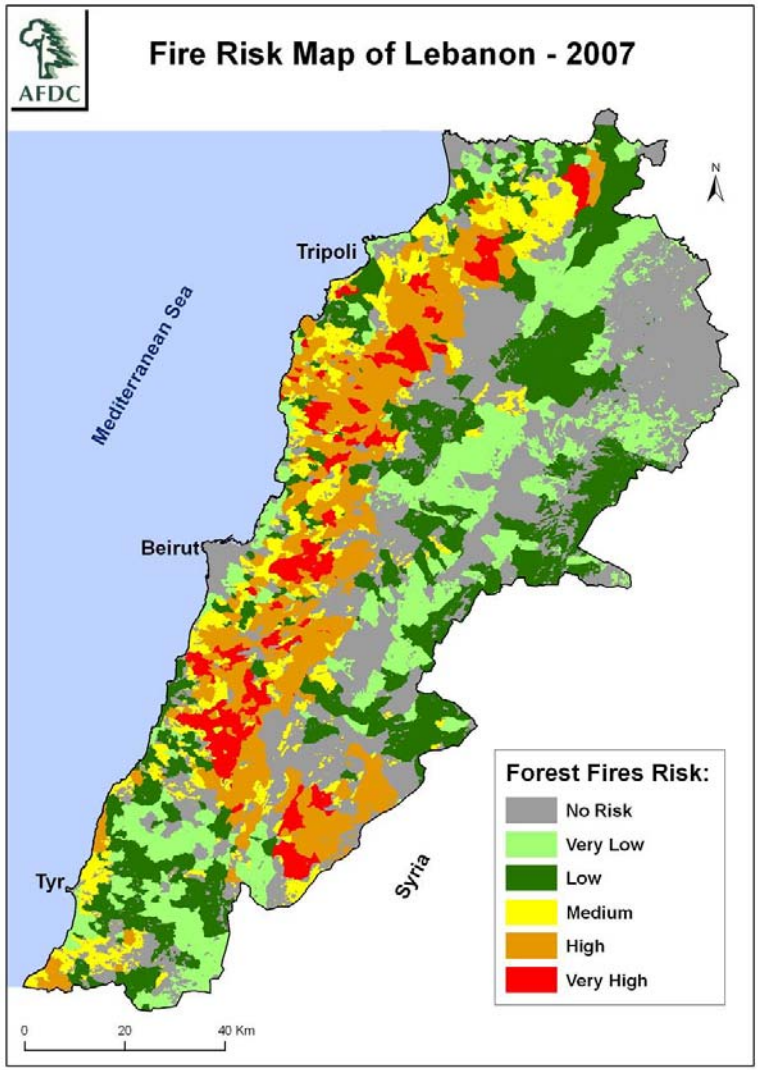
7èmes Journées géographiques
Télédétection, Statistiques, et Sciences Sociales: Quelles interactions pour quelles fins
Beirut, 29-30 April 2009

Fires in Lebanon

- Annually, an area of 1500 to 2000ha is burned
- Exceptionally, more than 3700ha of forested lands in the year 2006-2007
- Forests burned in 2 days in Oct 2007 (1500ha) equal 3x all forestation done in the past 17 years
- The consequences of forest degradation in Lebanon will be disastrous on:
  - The natural environment and ecological systems
  - Communities by increasing poverty and lowering the quality of life

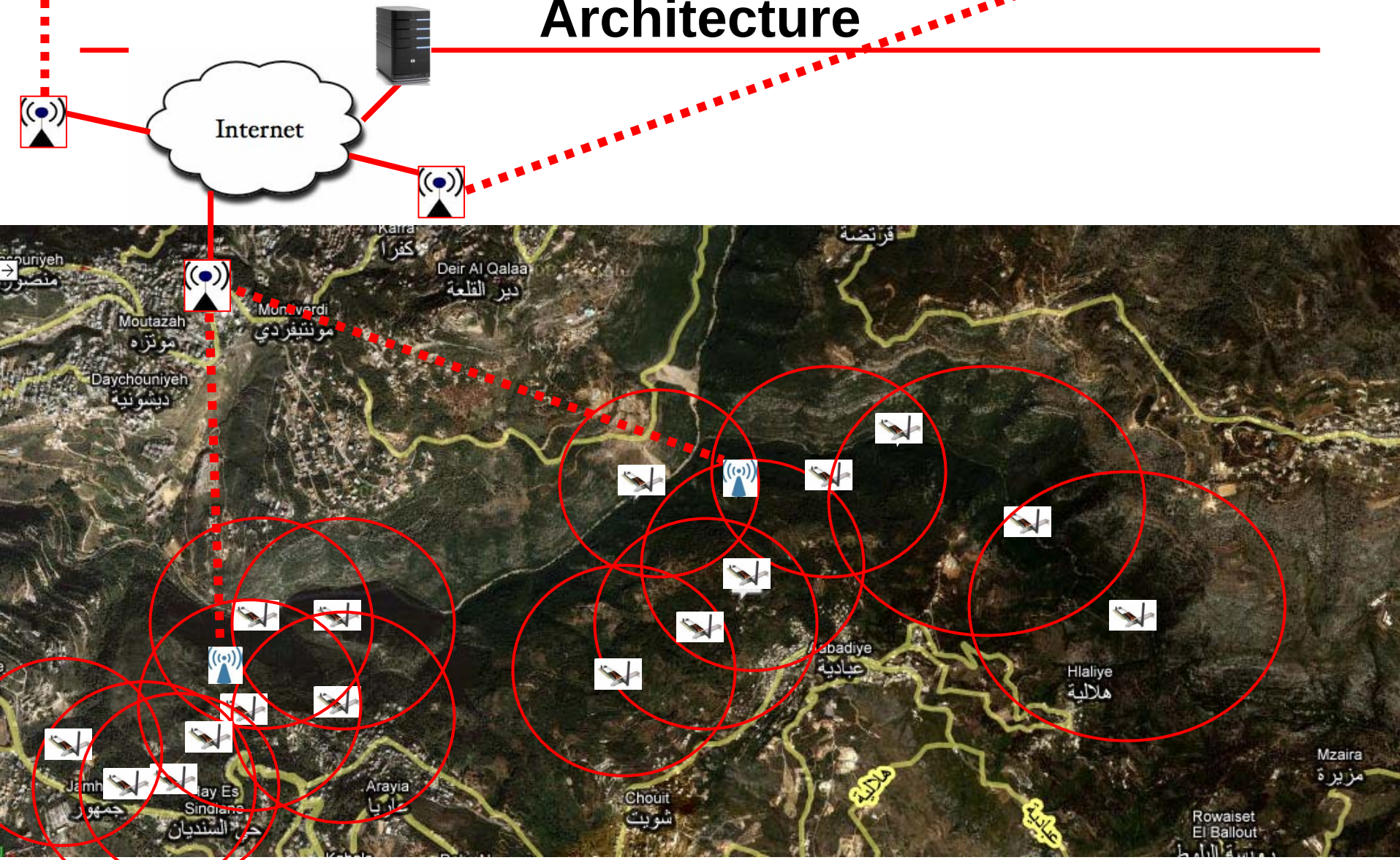
Forest Fire Map



Wireless Sensor Networks

- Functionality
  - Fire detection
  - Fire prediction
- Requirements
  - Real-time
  - Autonomous
  - Long life
  - Weather resistant
  - Remotely programmable
  - Environmentally friendly

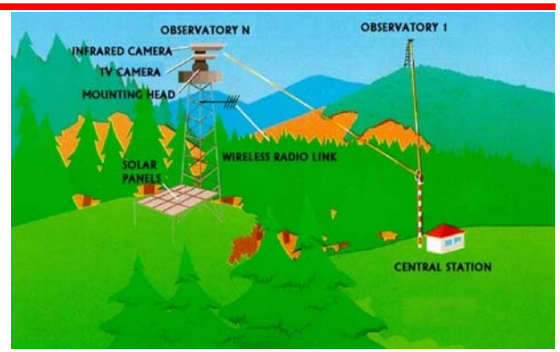
Architecture



Alternative Approaches

- Cameras
  - Optical
  - Infra-red
- UAVs
- Satellites

Cameras



Agent based data collecting in a forest fire monitoring system
Bodrozic, Ljiljana; Stipanicev, Darko; Stula, Maja;

- Optical
  - Direct vision
  - Zoom/tilt versatility
  - Large coverage areas (~7km radius)
  - Drawbacks
    - Human element required
    - Mounted on elevated towers (>30m)
    - Line of sight (deployment)
    - Triangulation (overlapping coverage areas)
    - Stations for communication
      - High bandwidth requirement

Distributed Intelligent Automatic Forest-Fire Detection SystemGrenoble
Martinez-de Dios J.R., B. C. Arrue and A. Ollero

Cameras

- Infra-red
  - Common with optical cameras
  - Fires are bright in the infrared
  - Advantages
    - Detection of heat
    - Confirmation
  - Disadvantage: False alarms
    - Solar reflections
    - Artificial light
    - Human activity

http://news.thomasnet.com/images/large/819/819696.jpg

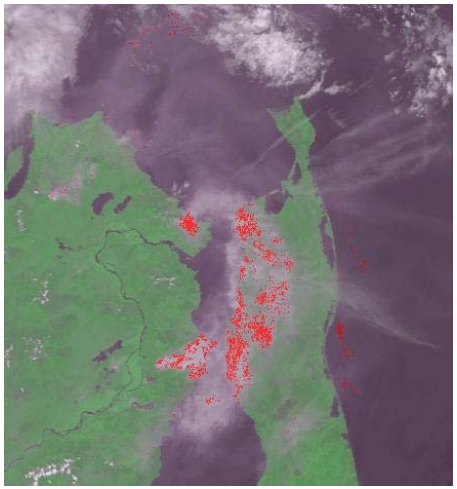
UAV

- Big coverage areas (1500 km2/hr)
- High cost (Cheap ones ~$7000)
- Personnel Training
- Limited flight range
- Communication in mountainous areas
- Lack of continuous coverage
- Useful only for detection

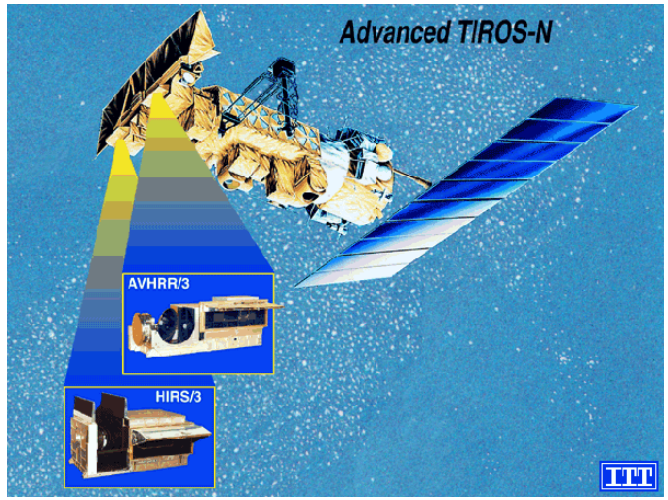
http://news.cnet.com/i/ne/p/2007/910ikhana550x381.jpg

Satellite

- Affected by weather
- Costly
- Large fires to be detected

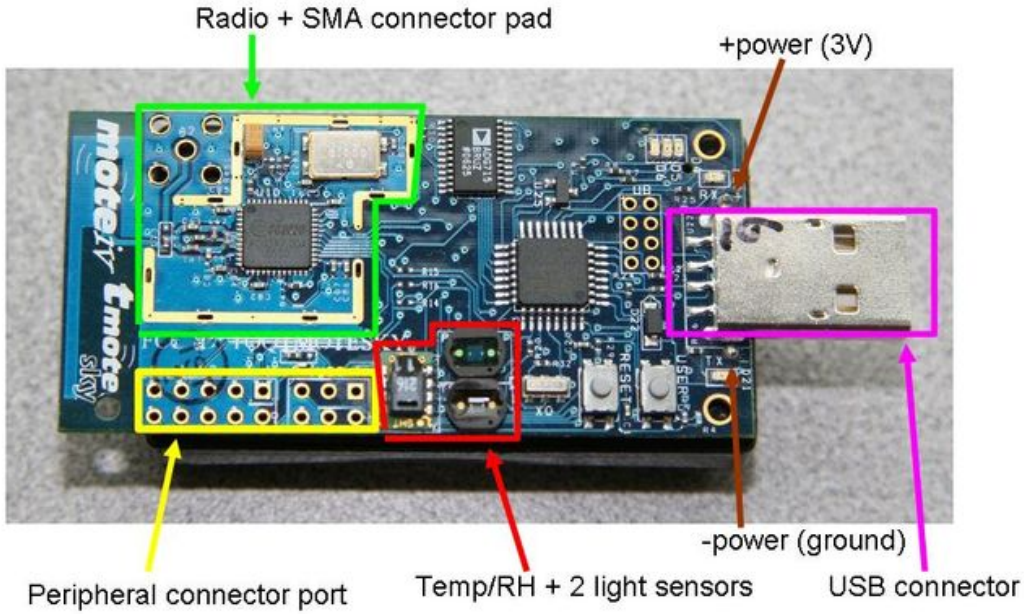


Forest fire smoke analysis in Far East Russia Kawano, K.; Kudoh, J.;



http://www.eoc.csiro.au/cats/calwatch/tiros.gif

Platform



http://robfatland.net/seamonster/images/7/71/Tmote_single_slide_labeled_wid700.jpg

Platform

- CPU – MSP430
  - Support for tinyOS
  - Ten I/O ports
  - Development board
- Xbee wireless chip
  - Functions on the 802.15.4 (ZigBee) protocol
  - Power optimized
  - Range
    - Xbee (90m)
    - Xbee Pro (1.6kms)

http://embedded-system.net/embedded-system/images/ti-ez430-f2013-usb-stick-board-for-msp430-development.jpg

http://www.digi.com/images/products/prd-xbeemoduleseries1.jpg

Sensors

- Temperature
- Humidity
- Smoke
- Gas
- Light intensity

Sensors

- Temperature
  - Simple and easy to acquire
  - Very cheap
  - Helpful in fire prediction

http://www.pittjug.org/b2b/pics/QCSE_NTC_temperature_sensor.jpg

http://www.humiditysensor.info/images/HC1000.jpg

- Humidity
  - Helpful in predicting fires (Fire Weather Index)

Gas Sensors

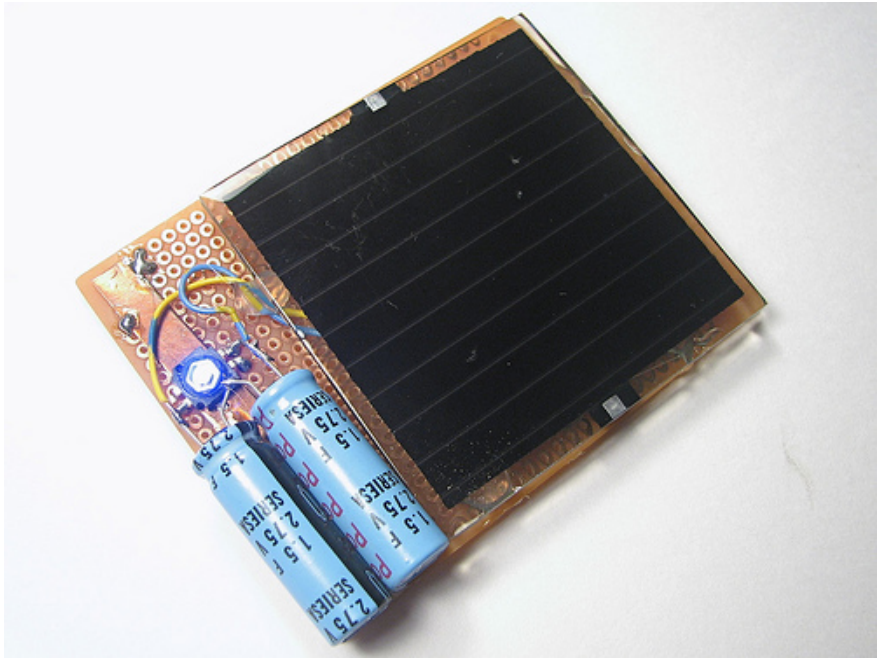
- CO_2
- CO
  - Incomplete combustion
  - Smoldering fire
- Methane
  - Fire prediction
  - After rainfall
- Cost

http://www.sensorsdirect.co.uk/USERIMAGES/DSC03291(1).JPG

http://www.sensorsdirect.co.uk/USERIMAGES/thumb_DSC03344(3).JPG

Power Management

- Primary source (solar panel)
  - Size
  - Positioning
  - Cost



http://farm4.static.flickr.com/3195/2963946250_6397e4385b.jpg

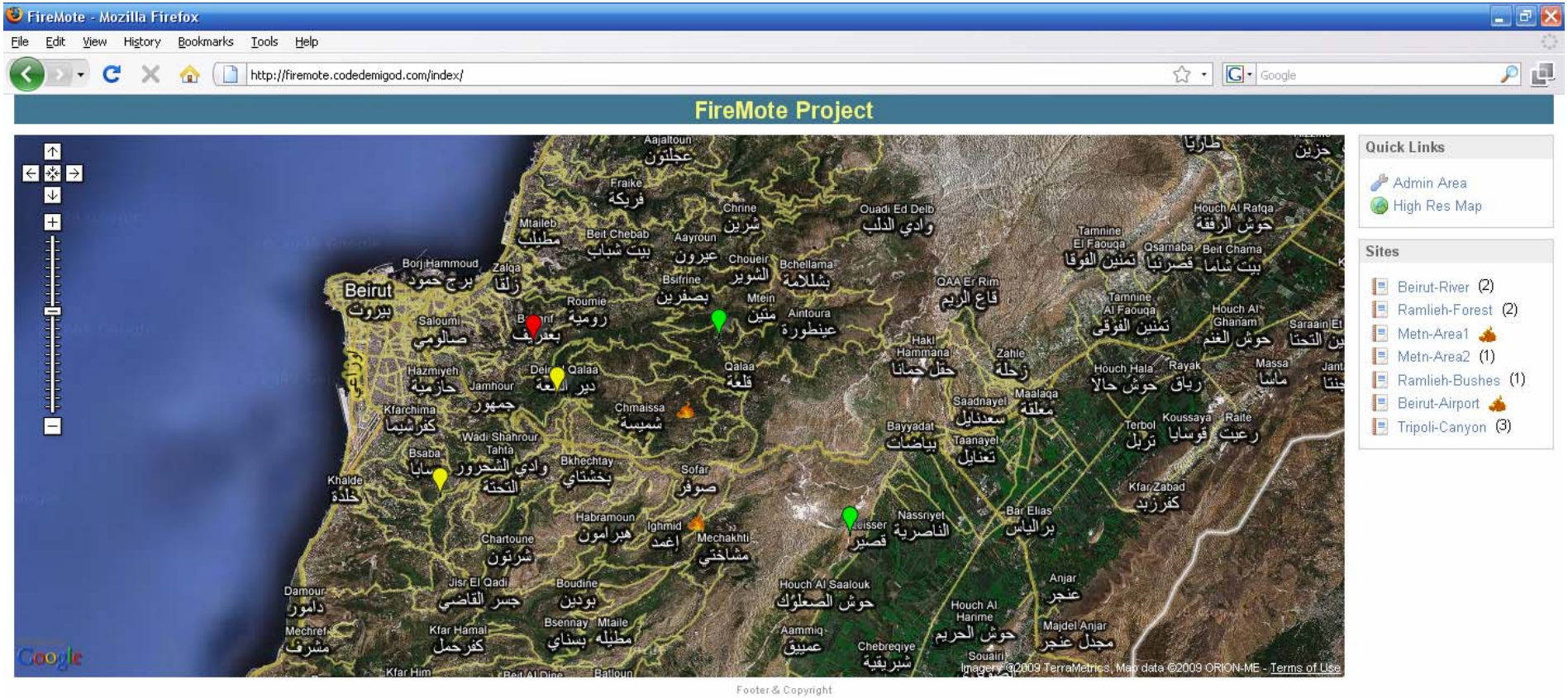
http://www.evilmadscientist.com/article.php/solar

Currently

Website

- Real-time data and alerts
- Prediction
- Site information (water outlets, closest hospital, etc…)
- Limited fire tracking

Website


FireMote - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://firemote.codedemigod.com/index/
FireMote Project
Quick Links
Admin Area
High Res Map
Sites
Beirut-River (2)
Ramlieh-Forest (2)
Metn-Area1
Metn-Area2 (1)
Ramlieh-Bushes (1)
Beirut-Airport
Tripoli-Canyon (3)
Beirut
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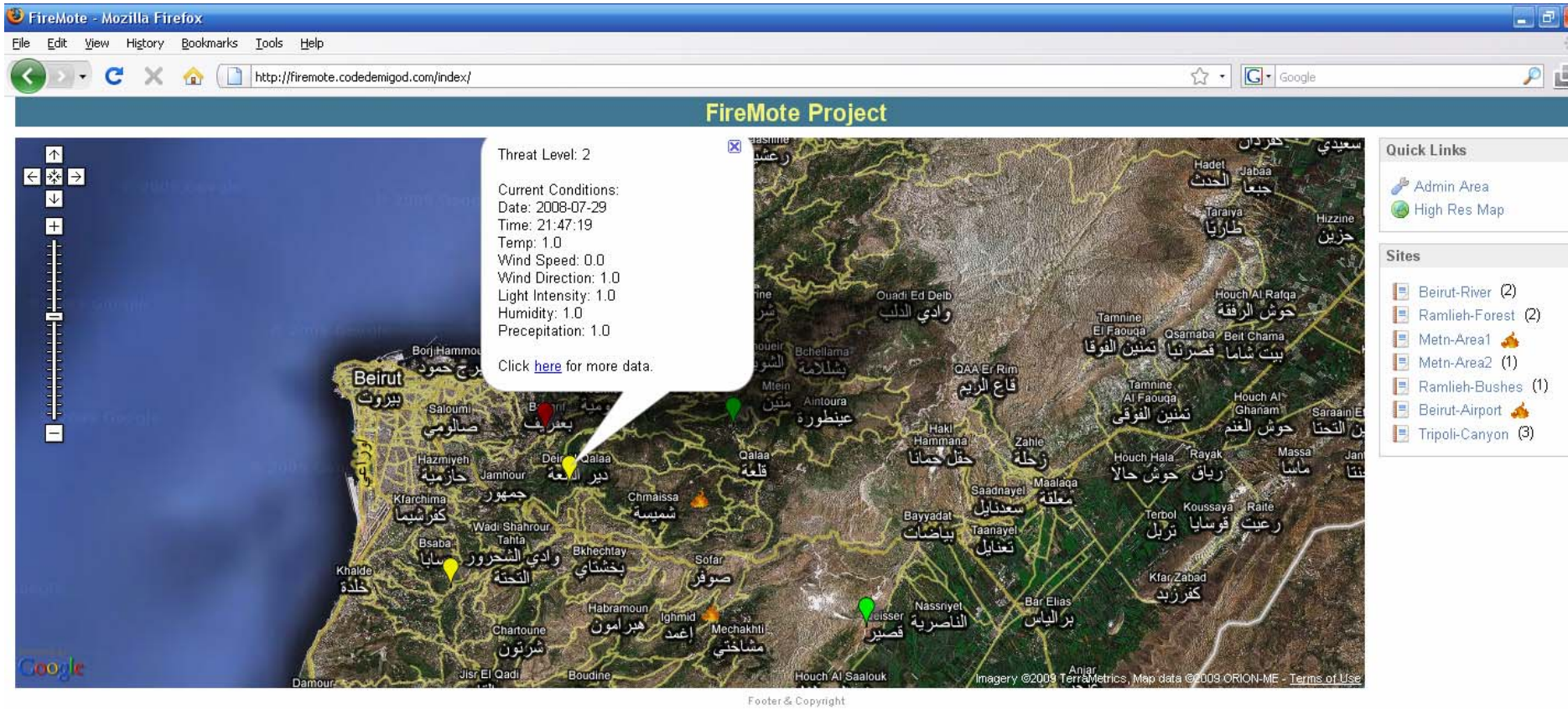
Website


FireMote - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://firemote.codedemigod.com/index/
FireMote Project
Threat Level: 2
Current Conditions:
Date: 2008-07-29
Time: 21:47:19
Temp: 1.0
Wind Speed: 0.0
Wind Direction: 1.0
Light Intensity: 1.0
Humidity: 1.0
Precepitation: 1.0
Click here for more data.
Quick Links
Admin Area
High Res Map
Sites
Beirut-River (2)
Ramlieh-Forest (2)
Metn-Area1
Metn-Area2 (1)
Ramlieh-Bushes (1)
Beirut-Airport
Tripoli-Canyon (3)
Beirut
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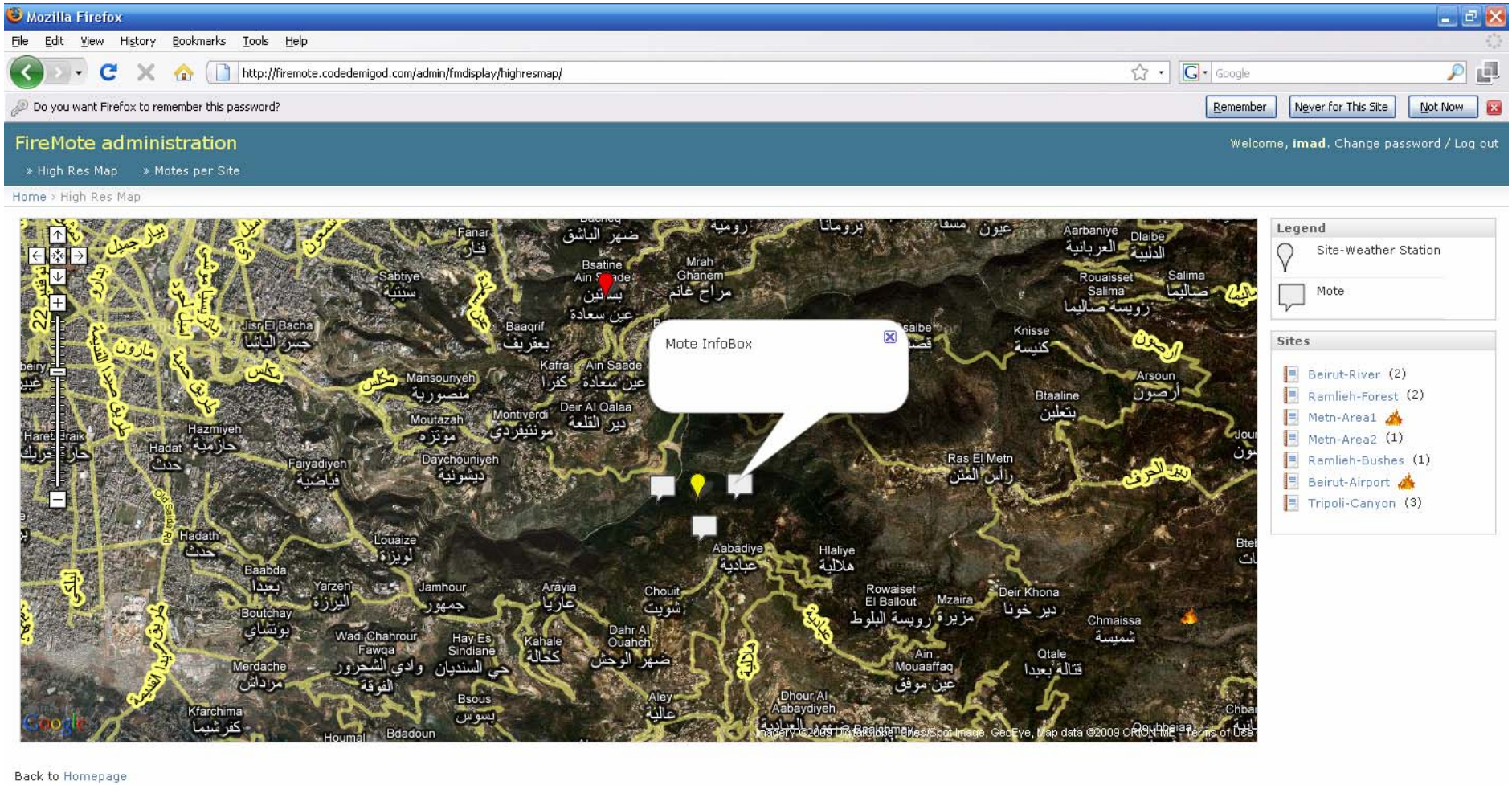
Website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Do you want Firefox to remember this password?
Remember
Never for This Site
Not Now
FireMote administration
Welcome, imad. Change password / Log out
» High Res Map
» Motes per Site
Home › High Res Map
Mote InfoBox
Legend
Site-Weather Station
Mote
Sites
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Metn-Area2 (1)
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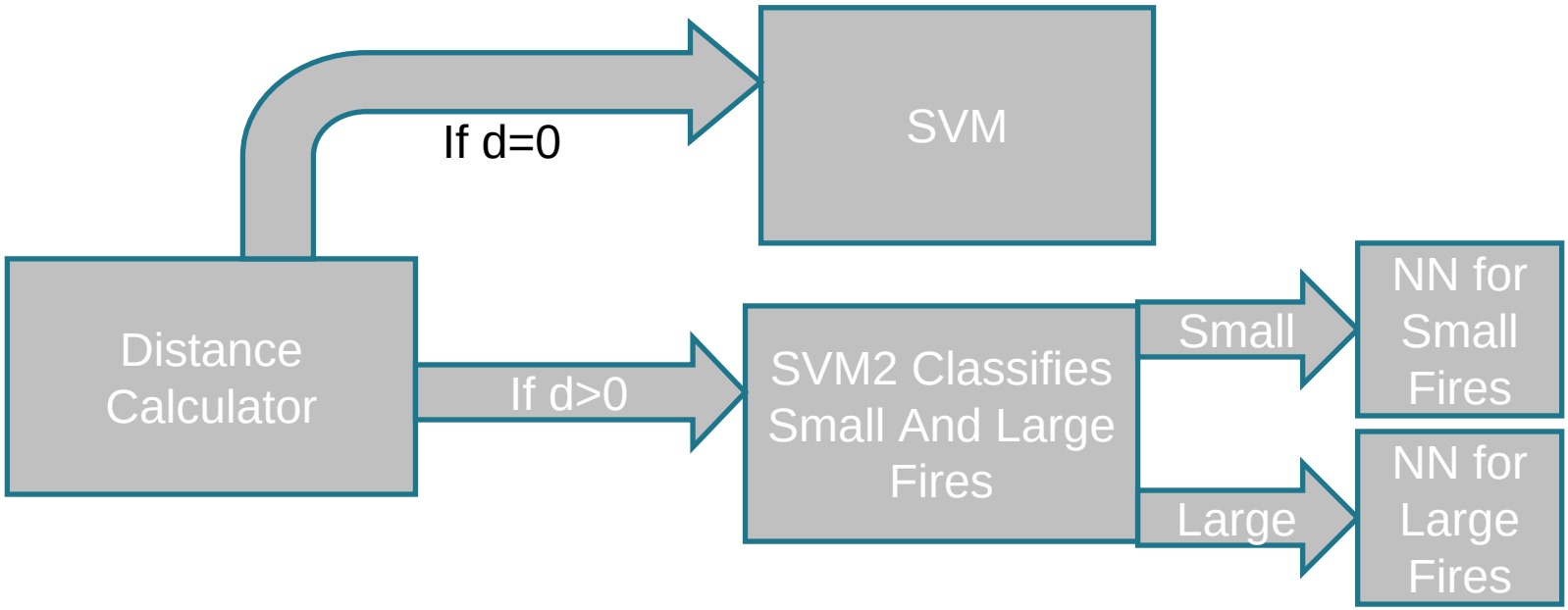
Back to Homepage

Prediction Algorithm

- SVM and Neural networks were combined to predict the estimated area of fire
- Features Selected (Fire Weather Index)
  - Wind Speed
  - Precipitation
  - Temperature
  - Relative Humidity
- Improvement of more than 300% on previous work
- Mean absolute error 8.7ha

Prediction Algorithm



Current Prediction Algorithm

- NN estimation
- Monthly risk scale of 1 to 5
- Moving towards a probability of occurrence
- Using:
  - Averages previous year
  - Averages previous month

Current Status

- Website first release
- Connection of motes to website done
- In progress
  - Prediction algorithm testing
  - Connection of sensors
  - Solar power charging
- Next step
  - Testing

What we Would Like to Answer?

- How fast can you detect a fire?
- How far after a fire spreads?
- How many sensors do I need to cover a certain area?
- How much would it cost?
- How accurate is your prediction?

Thank You

Questions?