PERECO - Personalized Emergency Response Ecosystem

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Introduction

- Emergency management (or Disaster management) involves the creation of plans through which communities reduce vulnerability to hazards and cope with disasters.

- Disaster management does not avert or eliminate the natural disasters or threats, instead it focuses on creating plans to decrease the impact of natural disasters.

- Failure to create a plan could lead to damage to assets, human mortality, and lost revenue.

- The Federal Emergency Management Agency (FEMA) has set out a basic four-stage vision of emergency management and planning flowing from mitigation to preparedness to response to recovery: Mitigation, Preparedness, Rescue, Recovery.
Introduction (contd.)

- It is important to note that one of the most important aspects of emergency or disaster management is Prevention.
- This phase was not in the original four phases of emergency management as described above.
- However, it is a crucial part of any disaster management plan and focuses on preventing the human hazard, primarily from potential natural disasters or terrorist attacks.
- Preventive measures may be taken on both the local, national and international levels.
A Case Study: Uttarakhand Floods of 2013, India

• The 2013 North India floods” as it is termed, left tens and thousands of inhabitants as well as pilgrims stranded or swept away due to the floods, in addition to inflicting considerable damage to assets, property and businesses.

• As of 16 July 2013, according to figures provided by the Uttarakhand government, more than 5,700 people were "presumed dead."

• The IMD had issued advance warnings as early as 13 June, 2013 that flash floods are imminent and had even identified districts and regions as very high-risk zones.

• These warnings were not disseminated to local inhabitants, pilgrims or tourists in that region. This demonstrated a complete lack of co-ordination between various governmental agencies, and consequently, no actionable information or warnings was made available to the thousands of innocent victims of this unfortunate incident, who were completely unprepared to face such a devastating disaster.
Motivation

- A preventive or proactive solution could have:
  1. Leveraged the early warning data made available,
  2. Processed that, and
  3. Disseminated actionable information in a targeted manner to the people on the ground.

- This could have possibly led to thousands of more lives being saved and also reduced property and asset damage caused as a result of this natural disaster.

- PERECO is this proactive solution.
SYSTEM DESIGN

Cloud Backend:
1. Geo-fencing: Identification of safe and unsafe zones
2. Developing most optimal route for every user
3. User monitoring and re-routing
4. Accident response and rescue

Textual data from various sources and agencies.

Data source

Triggers

Data source

Triggers

Message broadcast to user mobile device

Cloud backend provides actionable information to user, proactively and optimally guiding the user to a safe zone.

Mobile device

User location updates from mobile to cloud backend
Geo-fencing

• A geo-fence is a virtual boundary defined by a series of latitude and longitude co-ordinates around a particular region.

• In the weather or advance warning data, suburb or district names are identified as potential high-risk zones. Based on this geographical data the system receives, the geofencing component outputs a series of latitude and longitude co-ordinates that together geofences a potential danger or high-risk zone.

• Additionally, with the data received, this component also identifies the nearest “safe-zones” outside of the geo-fenced danger zone, which is considered as a safe region for our users., process that and disseminate actionable information in mass, to the people on the ground could have possibly led to thousands of more lives being saved and also reduce property and asset damage caused as a result of this natural disaster.
Routing

• This is the component that individually determines the most optimal escape route for each user in the danger-zone, thereby directing them to safety.

• The routing is highly personalized for each end user involving both optimal routing to the safe-zones and the load distribution among them.
Real-time Monitoring

- The cloud backend is constantly updated with locations of our users, from the mobile application running on the end-user phones. Thus the backend always has a big-picture of the entire on-ground situation at any instant of time.

- The mobile application also has an option to report obstacles. On receiving such a trigger from any user mobile application, the cloud backend engages the re-routing component.
Accident detection

Loved ones of victim notified of accident location and nearest hospital by SMS.

Nearest Emergency Response Unit is notified by server.

Phone detecting accident / accident reported

Victim transported

Nearest Hospital notified of incoming victim.
## India Weather Warning Bulletin

### Uttarakhand
Date: 13 JUNE 2013 (NIGHT)

<table>
<thead>
<tr>
<th>Met-Sub Division</th>
<th>Today (13 JUNE 2013)</th>
<th>Tomorrow (14 JUNE 2013)</th>
<th>15 JUNE 2013</th>
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<td>NIL</td>
<td>Heavy rainfall at isolated places</td>
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<td>Bageshwar</td>
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<tr>
<td>Chamoli</td>
<td>Heavy rainfall at isolated places</td>
<td>Heavy rainfall at isolated places</td>
<td>Heavy to very heavy rainfall at a few places</td>
<td>Heavy to very heavy rainfall at a few places with isolated extremely heavy falls</td>
<td>Heavy to very heavy rainfall at a few places with isolated extremely heavy falls</td>
</tr>
</tbody>
</table>

![Map of India Weather Warning Bulletin](image-url)
Phase 1: Detection
Phase 2: Routing Algorithm

1. Based on location reported from user’s device, those in the geo-fenced danger zone are immediately identified. Also, safe zones are identified around the geofenced danger zones using the same data.

2. These users are then clustered into groups. The number of clusters in a subregion within the danger zone is directly proportional to current user count in that subregion. The clusters geographic radius is restricted to 10 kms. This upper limit is imposed to ensure the algorithm does not irrationally increase the size of the cluster.

3. Every cluster thus obtained is a part of a graph G with the cluster itself as the source vertex and the safe zones as destination vertices. The various paths are edges of this graph with weights of the edges being proportional to the distance.

4. The number of such graphs will be equivalent to the number of such clusters, each cluster being the source vertex of its respective graph.
Routing Algorithm (contd.)

5. In each graph G do the following:
   1. The shortest path is found by selecting the edge with the least weight.
   2. When the capacity of safe zones is completely exhausted remove the vertex representing this safe zone from all the graphs.
   3. Therefore, each user in every cluster is now designated a safe zone and an optimal route to that safe zone.

6. During transit, in case any user reports a path blockage:
   1. Remove the edge corresponding to the path reported blocked from all graphs.
   2. Reassess an alternative optimal safe zone for each user on that path using the steps discussed above. Notify user of new directions to safe zone.
   3. Notify all users, in real-time via the mobile application, who are currently on that path with directions to the alternative safe zone.
Phase 3: Dissemination

The mobile application running on the user’s mobile device is launched automatically on receiving an emergency action message from the cloud back-end. The user is then directed to the nearest safe-zone.
Conclusion

1. “Prevention is Better Than Cure”

2. With the advent of mobile smart-phone technology, it has become increasingly easy for the dissemination of data to mobile smart phones, and processing of that data to give actionable information to the users.

3. This work attempts to define a new disaster response mechanism that connects two facets of emergency response namely prediction systems and enforcement of safety measures.

4. Additionally, this work proposes a method, using the same mobile application and cloud-powered backend to completely automate the process of detection, reporting and response to road accidents, considerably reducing delays in medical care reaching victims, thereby maximizing their chances of survival.

5. This overall framework that is developed is termed as PERECO - Personalized Emergency response Ecosystem.
Future Work

- Utilization of the geolocation data we collect, to help automatically identify road-accident hotspots and evacuation route bottlenecks.

- Analysis of this data facilitates the optimization of the placement of emergency response units and medical care facilities to minimize the time involved in delivering emergency medical care to any victim in that particular region.

- Ability to provide region-specific recommendations can be made, depending on the local conditions and resources available.

- Over time, with this actionable information at our disposal, our roads can be made safer for both pedestrians and motorists and our cities and towns could be much better prepared and equipped to handle any large-scale evacuation scenario.
References


Abbreviations

IMD : Indian Meteorological Department
FEMA: Federal Emergency Management Agency
SMS: Short Messaging Service
WHO: World Health Organization