UAV-Assisted Disaster Management: Applications and Open Issues

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Loss events worldwide 1980 – 2014
Number of events

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Geophysical events
(Earthquake, tsunami, volcanic activity)

Meteorological events
(Tropical storm, extratropical storm, convective storm, local storm)

Hydrological events
(Flood, mass movement)

Climatological events
(Extreme temperature, drought, forest fire)
Introduction

- Number of natural disasters increased up to 150% in last 30 years

- Efforts to recognize and forecast the disaster, react efficiently, assess the damage, and restore normal state

- We analyze applications of UAV-assisted systems in disaster management, and discuss about open issues and challenges
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Why UAVs?

- The most important issue that needs to be solved is to preserve human lives.
- The first 72 hours after the disaster hit are the most critical
- UAVs can provide fast overview of the situation
Disaster management stages

In this paper, we envision a three-stage operational lifecycle where UAVs participate in natural disaster management:

- **pre-disaster preparedness** – concerning surveying-related events that precede the disaster, static WSN-based threshold sensing and setting up Early Warning Systems (EWS)

- **disaster assessment** – providing situational awareness during the disaster in *real time* and completing damage studies for logistical planning

- **disaster response and recovery** – including SAR missions, forming the communications back-bone, insurance-related field surveys
Disaster management stages

**Stage I: Preparedness**
- Static threshold sensing
- Controller-directed surveying

**Stage II: Assessment**
- Real-time situational awareness
- Damage study for logistical planning

**Stage III: Response & Recovery**
- Supporting SAR missions
- Building communication links to RAN
- Insurance/governmental policy–related surveying

WSN Effectiveness

UAV Effectiveness
WSN and robot network for disaster management
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## UAV-assisted applications in disaster management

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UAV-assisted applications in disaster management

WSN and UAV-assisted applications in disaster management that are taken into account in this work are the following:

- monitoring, forecast and early warning systems,
- disaster information fusion,
- situational awareness and logistics,
- damage assessment,
- standalone communication system,
- search and rescue missions.
Monitoring, Forecast, and EWS

- Predicting the disaster by structural and environmental monitoring, and information analysis
- Disaster detection with early warning systems
- Dominant role of WSN
- Problem if the WSN does not have an appropriate reconfiguration mechanisms in case of faults caused by disasters – UAVs for WSN reconfiguration
Disaster information fusion

- Combining different sources of information available and/or making a bridge between different information technologies

- Becomes more important with the use of social networks for disaster management

- Example integration of smart data gathering and analysis system, communication system, WSN, social networks, etc.
Situational awareness and logistics

- Gathering precise information on the disaster scale and the situation on the field

- UAVs play critical role

- High volume data, low latency
Damage assessment

- Gathering information on the damage, structural inspection

- UAVs play important role, WSN usability questionable

- Speedup achieved by the simultaneous use of multiple UAVs
Search and rescue missions

- Searching for people affected by the disaster
- UAVs play important role, WSN usability questionable
- Accent put on different detection technologies
Standalone communication systems

- Application that get the most attention

- Establishing or re-establishing damaged or destroyed parts of the communication infrastructure

- Problems:
  - Maintaining the connection during longer periods of time
  - Capacity of such network
Other applications

- Infrastructure reconstruction
- First aid and supply delivery
- Real-time media coverage
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Open issues (i)

- UAV precise localization (indoor or urban environments)
- Multiple UAV control techniques and algorithms
- Sustainability of the network - handover issues, automatic charging
Sustainable UAV station
Open issues (ii)

- UAV physical constraints (resistance to weather conditions)
- UAV network security and robustness
- Privacy and trust issues
Challenges

- Performing optimal handoffs between the roles of surveying, communication with users, and data relaying

- Choosing the charging duration, i.e., making tradeoff decisions on whether charging instants should be proactive, even if their battery is not completely depleted

- Optimizing the number of hops by building accurate 3-D channel models for various weather conditions and land topologies

- Designing distributed control algorithms at different layers of the UAV-assisted disaster management system
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Conclusion

- UAV is a promising technology that can be used for disaster management
- Open issues have to be addressed properly in order for the technology to be fully adopted
- Perspectives of the use of UAVs largely depend on the legislation
Acknowledgements

Mahalo!

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