3D laser imaging techniques on UAVs

Detection and localization of collapsed buildings and trapped victims

INACHUS partners


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Scope of the project
Scope of the project

- Project facts & Consortium

Technological and Methodological Solutions for Integrated Wide Area Situation Awareness and Survivor Localization to Support Search and Rescue Teams - FP7 European project n°607522

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20 partners from 10 countries
8 Research institutes
8 Industrial partners
4 End users

Budget: € 13 944 268
EU funding: € 9 885 037

48 months, starting January 2015

A project in collaboration with ONERA, The French Aerospace Lab and a grant from Europe
Scope of the project

- **Project background**

  **Main idea** - Fast rescue of disaster surviving victims
  Situation & awareness simulation during structural collapses including detection of survivors & survival spaces

  Crisis incidents result in difficult working conditions for Urban Search-and-Rescue crews (USaR). INACHUS aims to achieve a significant time reduction and increase efficiency in USaR operations.

  - USaR ISSUES
    - WORK SAFETY
    - DIFFICULT VICTIM LOCATION
    - QUICK RESCUE
    - LIMITED SITUATION AWARENESS

  - USaR NEEDS
    - SAVE TIME
    - INCREASE EFFICIENCY
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**Simulation tools**
For estimating locations of survival spaces

**New sensors**
EM, vision, chemical…

**Snake robot**
Robots can go where humans can’t

**Decision and planning modules**
For damage estimation (airborne and ground-based data)
Data analysis and 3D visualization
Wide area surveillance tools for monitoring of collapsed buildings
Wide area surveillance tools
for monitoring of collapsed buildings

- **Objectives**

  1. Provide a **wide-area** disaster scene assessment
     Based on integration of space borne information and Finite Element Method results, and population distribution mapping, for 3D modelling and USaR prioritization

  2. Provide **high resolution** and quality 3D digital surface models
     Coming from laser scanner and photogrammetry data on the most affected areas

  3. Perform an **exploitation** of these 3D data
     Relation with the library of collapsed building models using a semantic analysis or matching method

  4. Assess the **structural damage**
     To deliver maps of survival space and rescue path as inputs to the COP

- **Expected results**

  - New methods to refine priority areas
    Based on satellite data + actual pop. dynamics estimation

  - High resolution 3D digital surface/terrain models
    Measured on a disaster site

  - Probability map of survival space, maps of rescue paths and dasymetric population

  - New data processing and fusion methods
    3D mapping (UAV / ground meas. + passive / laser)

  - New semantic analysis methods
    3D damage assessment and SoTA process

  - New matching methods
    3D damage assessment and SoTA Process
Wide area surveillance tools for monitoring of collapsed buildings

- **3D surface model**

Wide-area surveillance tools for monitoring of collapsed buildings
1. Wide area in limited resolution (~1 m) from drones
2. Small scale in high resolution (<10 cm) from ground and drones
Wide area surveillance tools for monitoring of collapsed buildings

- **3D surface model**

Wide-area surveillance tools for monitoring of collapsed buildings
1. Wide area in limited resolution (~1 m) from drones
2. Small scale in high resolution (<10 cm) from ground and drones

- Up to the area of a **city** in limited resolution
- Compact drones, easy to deploy and operate (less than 1 hour)
- Available under **bad weather conditions** (rain, fog, haze, wind)
- Available **H24** (day and night vision)
- Classification of the typologies (building, road, tree, vegetation,..)
- Maps of rescue paths
- Classification maps of buildings with associated survival probabilities

10 x 10 km²
Wide area surveillance tools for monitoring of collapsed buildings

- 3D surface model

Wide-area surveillance tools for monitoring of collapsed buildings
1. Wide area in limited resolution (~ 1 m) from drones
2. Small scale in high resolution (< 10 cm) from ground and drones

- From Quarter to Building levels in high resolution
- Autonomous outdoor flight (light-weight drones <5kg)
- Data fusion from Terrestrial and Airborne measurements

✓ Precise 3D reconstruction for visual analysis of buildings by USaR Teams
✓ Increasing operator interpretation by 3D / visible data fusion (damage evaluation)
Experiments Results
Experiments & Results

- **Involved technologies**

How to achieve a significant time reduction related to Urban Search and Rescue phase?
How to provide wide-area situation awareness solutions for improved detection and localization of the trapped victims?

1. 3D Laser scanner from the ground
2. 3D Laser scanner from a drone / gyrocopter
3. 3D geometry from image analysis

- 3D point cloud (FWF) on wide area from gyrocopter platform
Experiments & Results

- **Experiments**

  Experiments to collect **3D data** with aerial / ground-based systems ⇒ Dense high-accuracy data
  3D laser cameras (3D TOF) integrated on helicopter UAV and gyrocopter
  3D measurements in Ågesta, Lyon, Toulouse… Scenarios shared with ALL partners + End-Users

  Experiments in Lyon, France
  Real time display to the USaR team (video + 3D)
  Airborne and ground-based laser + photogrammetry data

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**Velodyne HDL32**

- **Weight**: 2 kg
- **Size (height x diameter)**: 150 x 100 mm
- **Range**: 70 m
- **Accuracy**: 20 mm (at 25 m)
- **Meas. rate**: 700,000 points/sec

**Vario Benzin characteristics**

- **Maximum Take-Off Weight**: 18 kg
- **Main Rotor Diameter**: 1.78 m
- **Overall length**: 1.63 m
- **2-cycle engine**: 26 cc
- **Autonomy**: 45 min
Experiments & Results

- Experiments

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Semantic data analysis, without damage model

Fused 3D point clouds + RGB camera

Semantic labelling of point clouds using deep learning (85%+ global accuracy), released in open-source for re-use and dissemination: https://github.com/aboulch/snapnet
Experiments & Results

- Experiments

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Semantic data analysis, without damage model

Transfered SnapNet #1
Urban semantizer to detect buildings and terrain vegetation

SnapNet trained on urban classes

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Experiments & Results

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Semantic data analysis, without damage model

Transfered SnapNet #2
Rubble predictor

SnapNet trained on intact/damaged (Montebello dataset annotated for rubble detection by ONERA)

Semantic labelling of point clouds using deep learning (85%+ global accuracy), released in open-source for re-use and dissemination: https://github.com/aboulch/snapnet
Experiments & Results

- Experiments

Experiments to collect **3D data** with aerial / ground-based systems ⇒ Dense high-accuracy data

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Semantic data analysis, without damage model

Combined: Inachus tools for building + rubble 3D map with demolition estimate

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Experiments 

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  **Semantic data analysis, with damage model**

Airborne and ground-based laser data + photogrammetry data + Exploitation
Experiments & Results

- Simulations at ONERA including Physics

  Performance validation and simulation of the systems
  Numerical 3D data point clouds
  To test / define strategies of airborne observation considering both ethical issues and USaR requirements

MATLIS code for 3D Laser Scanner performance analysis
End-to-end / Physical model including optical properties of materials, turbulence effects, bad weather conditions…
Synthesis Perspectives
Wide area surveillance tools
for monitoring of collapsed buildings

- **Next steps for the project**
  
  To achieve a significant time reduction related to Urban Search and Rescue phase
  To provide wide-area situation awareness solutions for improved detection and localization of trapped victims

- **Expected results**
  
  New methods to refine priority areas
  High resolution 3D digital surface/terrain models
  Probability map of survival space, maps of rescue paths and dasymetric population
  New data processing and fusion methods
  New semantic analysis methods

**Last pilot of the project**

12 – 16 November 2018
at the French / Italian border
between the Alps and the French Riviera

Feel free to join us!

L’Aquila, Italy after several earthquakes