Volcanic Environments

Robots for Exploration and Measurement

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Introduction

- The study of volcanic activity is important from a scientific point of view as it allows for a better understanding of one of the most spectacular geological phenomena and of the working principles that are at the basis of geophysics.
- Most of the measurements necessary for a comprehensive analysis of what is taking place inside a volcano should be taken in the proximity of the craters.
- The knowledge of when and how a plume of volcanic ash will be emitted is useful for the advanced planning of route modifications, and if need be, flight cancellations; thereby, this information can help reduce inconvenience and discomfort to passengers.

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Importance of Robots for Measurements in Volcanoes

- Reduce the level of risk involved for volcanologists who are working too closely to volcanic vents during eruptive phenomena.
- Measurement of variables relevant to the investigation of volcanic activity (visual, thermal images, gas analysis and sampling).
- Several environmental constraints must be taken into account in the developmental phase of a robotic system that is to be adopted in volcanic areas (Terrain, Temperatures, Gases, and Weather Conditions).

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Other projects concerning Robots and Volcanoes

Figure: Dante II[1]

[1] Copy of http://syahbta.blogspot.com/2010/10/4-kandidat-pengganti-mbah-marijan.html

Figure: Rover Marsokhod[2]

[2]Copy of http://www.sciencephoto.com/media/337613/enlarge

Figure: Yamaha RMAX[3]

[3]Copy of `http://www.yamaha-motor.co.jp/global/news/2002/02/06/sky.html`

Figure: UAV Makers AAI & Aerosonde[4]

[4]Copy of http://www.defenseindustrydaily.com/textron-buys-uav-makers-aai-aerosonde-03968/

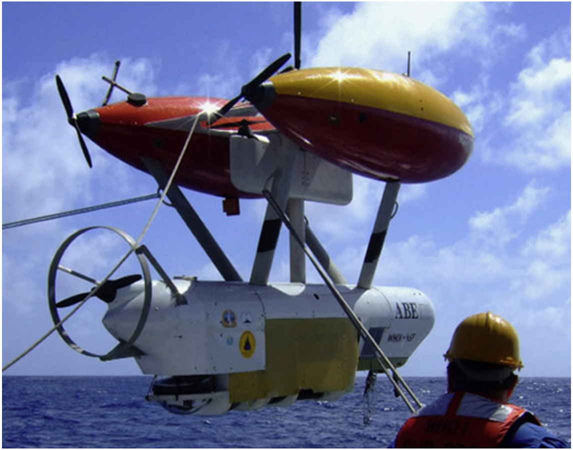

Figure: Autonomous Benthic Explorer (ABE)[5]

[5] Copy of http://oceanexplorer.noaa.gov/explorations/10chile/background/plan/media/missionplan3_es.html

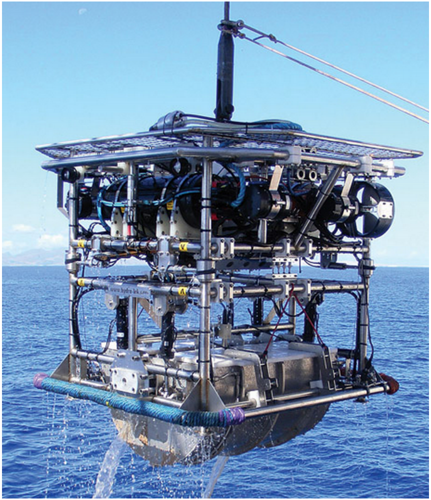

Figure: HyBIS[6]

[6]Copy of http://www.intoceansys.co.uk/articles-detail.php

Prototype Robots

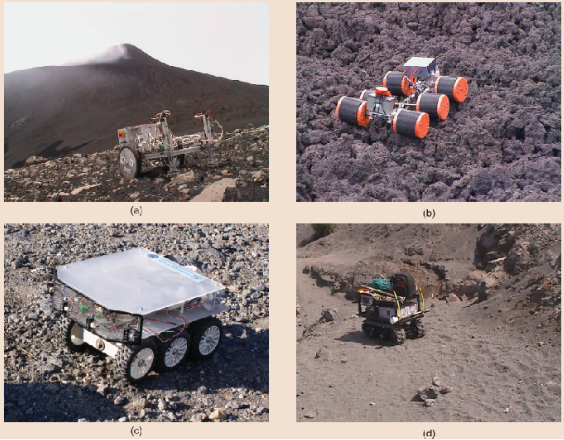

Figure: (a) Wheeleg in action, (b) M6 on volcanic terrain, (c) P6W robot, (d) U-Go robot[7]

[7]Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 43

Prototype Robots

	Wheeleg	M6	P6W	U-Go
Locomotion	Two front legs (pneumatic) and two rear wheels (dc motors)	Six wheels independently actuated by a stepper motors inside each wheel	Six wheels independently actuated by independent dc motors	Rubber tracks (dc motors)
Main features	Hybrid locomotion architectures	Highly adaptive chassis: each pair of wheels is jointed to the other with a prismatic and rotational joint with variable stiffness	Smaller scale prototype of the ROBOVOLC system for traction control strategies test, field-programmable gate array (FPGA)-based low-level control architecture	Two control modalities: teleoperated and autonomous, 200-kg payload
Dimensions $W \times L \times H$ (cm)	$66 \times 111 \times 40$	$71 \times 75 \times 15$	$20 \times 30 \times 20$	$70 \times 120 \times 110$
Weight (kg)	25	10	3	250
References	[15], [16]	[17]	[18]–[20]	[25], [26]

Figure: Table Specifications.[8]

[8] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 44

Robot

Figure: ROBOVOLC in action on top of Mt. Etna.[9]

[9] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 45

Figure: ROBOVOLC in action on rocky terrain.[10]

[10] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 45

The Mechanical Platform

- The Mechanical Platform.
- Control Hardware Architecture.
- Navigation and Localization System.
- The Science Sensor Package.

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Control Hardware Architecture

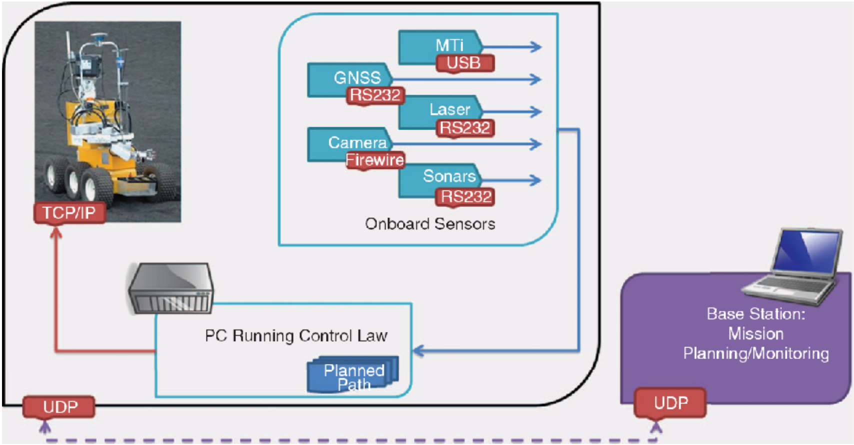

Figure: Navigation System Control Architecture.[11]

[11] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 46

The Science Sensor Package

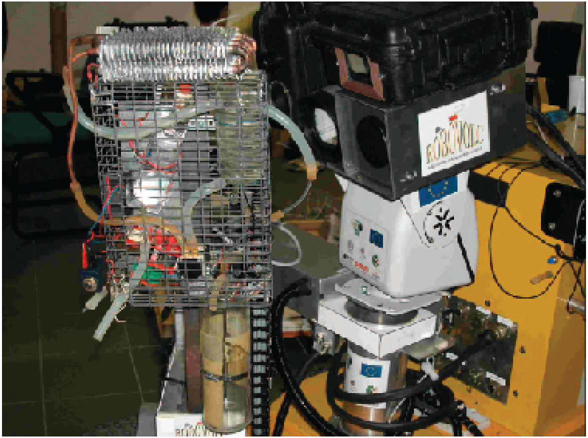

Figure: The gas sampling system on the left and the pan-tilt turret on the right.[12]

[12] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 46

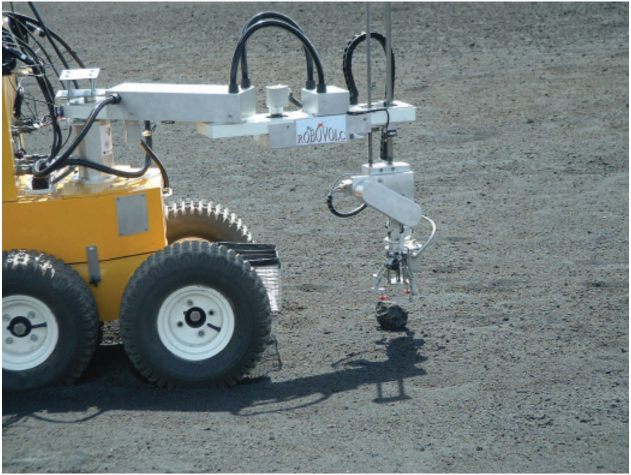

Figure: Rock sampling with the ROBOVOLC manipulator.[13]

[13] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 47

Scientific Data Collected

- Video Camera Images.
- Infrared Camera Images.
- DGPS Data.
- Still-Image Camera and Stereo Images.
- Gas Sampling and Analysis.
- Doppler Radar.
- Rock Collecting.

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Video Camera Images

Figure: Example image of hot lava flow [14]

[14] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 47

Infrared Camera Images

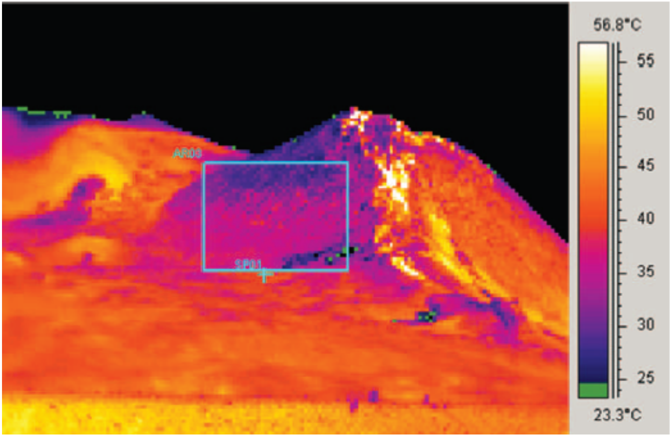

Figure: Example Crater viewed form the IR camera [15]

[15] Image copy of "*IEEE Robotics And Automation Society*", Volume 19 No. 1 March 2012 ISSN 1070 – 9932 `http://www.ieee-ras.org/ram`, page 48

Conclusions

- The adoption of robotics in volcanology is still in its infancy, since only few prototypes have been realized, and most of the research activity needs further investigation and resources. Despite this, robots have shown to be quite useful for environmental measurements and, in general, for taking measurements in dangerous locations.
- The performed research activity in the development of robots for volcanic measurement and exploration allowed us to better understand and solve problems related to the adoption of robots in extreme environments, as well as in other contexts such as search and rescue along with operations in other hazardous situations and areas.

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- The Volcan UAV, the U-Go robot, and the ROBOVOLC system are maintained operative and are now useful tools for the volcanologists of INGV, being used each year in several missions, both to perform measurements and to further develop robotic strategies.

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Bibliography

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Article: Volcanic Environments Robots for exploration and Measurement By G. Muscato, F. Bonaccorso, L. Cantelli, D. Longo, and C.D. Melita.