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Chapter 27
Digital and Mechatronic Technologies Applied to the Survey of Brownfields

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ABSTRACT

The brownfields are amongst the most relevant historical evidences of the socio-economic heritage of populations. The rehabilitation of these sites, often aimed at inserting them in a newly conceived connective tissue of the cities, requires complete and accurate knowledge of their historical and architectural value: the former use of spaces, constructive technologies, environmental conditions and present deterioration must be investigated. The width and complexity of these architectural/urban areas requires complex survey methodologies. These analyses take advantage from digital mechatronic tools such as hybrid rover equipped with sensors to provide information on the damage of structures, degradation of plaster and in general on the state of the materials forming the different parts of the brownfield. This Chapter analyze a procedure combining traditional survey with mobile robot technology, aimed at recovering the geometrical and architectural features of these complex sites. The mechatronic survey is schematized as composed by main five tasks, which are described in the Chapter.

INTRODUCTION

The analysis and representation of architectural complex phenomena which due to their size span from the architectural to the urban scale, require a multidisciplinary approach: their survey, carried out to support the decision-making of administrators, should be able to provide a global knowledge, including a qualitative and quantitative description of the countless number of physical variables, but

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also of the economic and social characterizing factors.

The brownfields represent a remarkable example of such complex sites. Due to the dimensions of the occupied areas, these former industrial sites are larger than the typical architectural manufacts such as buildings, smaller in comparison with the urban environment. The industrial sites have become brownfields after a gradual abandonment due to various reasons, often including the considerable costs for the modernization of equipment and the more restrictive rules in terms of control of the environment and limitation of emission of contaminants.

In Europe, the abandonment of these places reached its apex in the seventies of the last century, firstly occurring in great centers deputed to the production of iron and steel, and then extending to other production system such as paper mills, woolen mills, felt mills etc.

There are many different definitions of brownfields in the literature. In the European context, a working group named CLARINET defines brownfields as "sites formerly destined to some use, now derelict or underused, having real or perceived problems with contamination of the environment. They are mainly located in developed urban areas and require works to bring them back to a beneficial use" Clarinet (2002). Looking at the degree of contamination, three different types of abandoned industrial areas can be distinguished:

- *Uncontaminated area* - when contamination detected in the environmental is lower than the threshold for the concentration of contaminants or lower than the values of the threshold concentration of risk;
- *Contaminated area* - when the values of the threshold concentrations of risk are exceeded;
- *Potentially contaminated area* - where one or more concentration values of pollutants in relevant environmental matrices are higher than the values of the threshold concentration of contamination, in waiting to carry out operations for the characterization and analysis of health and environmental risks.

In Italy the term brownfield is typically given to abandoned industrial area where the pollution level violates the environmental regulation, and for which a remediation project is prescribed or undertaken. Sometimes, these sites may fall in those areas where standard reclamation activities cannot be applied (e.g. close to sensitive buildings or infrastructures).

Indeed the brownfields represent real urban "voids" together with a source of degradation. Their recovery is considered an unavoidable and delicate step to improve the environmental sustainability of the city. As a confirmation, the recovery of these sites is considered an important factor for improving the environmental sustainability indices (ESI) of different countries, as described in Pelliccio and Giovinco (2014) and the European Union has declared the recovery of these areas among the objectives of the Europe 2020 strategy.

Therefore, the complexity of these architectural/urban sites necessitates a complete survey able to provide a sufficiently complete and schematic knowledge able to drive the development of guidelines for the recovery of the sites.

Generally these sites are mainly located in densely urbanized or vulnerable areas such as riversides and sea shoreline and often occupy areas of many hectares. These sites have often grown with time, both in terms of areas and volumes, depending on the needs of the production and finally they have become ''*architectures assembles*" combining different types of geometries, structures and building technologies consistent with the construction periods. Often the access to the original buildings, mostly in the basement floor, is impeded as spaces are filled with former industrial debris, waste materials and unsold products (Figure1).

Figure 1. _a_b. Paper mill of Ceprano (Italy). Underground sites inside it.

To find a new use to brownfields and to conceive an architectural/environmental plan for their redevelopment, an analysis is compulsory able to return a schematic interpretation of these sites. The survey needs a multi-criteria approach based on the identification of technical-architectural contents for the management of the recovery process and on compatible uses tied to a proper economic revitalization of the area as well. In the last few decades there has been a considerable increase on the use of computer technology and digital devices to enrich and complete the "traditional survey" process: geographical information system (G.I.S), laser scanner, remote sensing, digital thermography, global positioning system (GPS) and, more recently, drones with integrated systems of different sensors as cameras, GPS, LIDAR etc., are able to return dataset of metric, geometric and material information, often integrated in a 3D graphic model.

Among the different advantages, the remote sensing systems allow the survey of not accessible areas (see for instance the drones or lidars, able to fly on relatively wide areas and provide detailed information).

Currently, in spite of major technological innovations, there is still the difficulty of exploring areas inaccessible to operators, even with the use of remote sensing instruments. Subterranean cavities, spaces inundated with water or filled with accumulated debris, as in the case of earthquakes, archaeological sites are just few enlightening examples. Furthermore, when these places have a relevant cultural value, non-invasive investigations are required for their exploration, e.g. to know the material forming the floor of cavities and contemporarily preserve important historical evidences.

In this view, brownfields may be seen as interesting examples of industrial archeology, where the access is often difficult due to the presence of invasive and pollutant debris. Aerial surveys like drones equipped with cameras or thermal imaging camera sensors, with stabilized GPS and automatic flight mode may give a whole and general depict of the area. However such equipment do not allow to investigate zones of particularly low heights. This problem can be solved by the joint use of digital technology and mobile mechatronics system.

In the last decades, mobile systems belonging to a class of Robots have started to be applied and implemented for large number of non conventional applications such as inspection as discussed in Bekhit et al. (2012), remote exploration as proposed in Dubowsky et al. (2006), rescue as discussed in Kececi (2009), service (Morales et al., 2006), defense, manufacturing, cleaning, and even entertainment. Mobile robots are mechatronic systems and they can be classified according to the type of locomotion they perform, namely wheeled, tracked, legged or hybrid as detailed in Sandin (2003).

Wheeled and tracked systems can perform fast and robust motion on a smooth surface, but they are rather ineffective in overpass obstacles with a size greater than or equal to the radius (dimension) of the wheel (track). Legged robots can perform robust motion either on flat surface but also on rough terrain, indeed they have a potentiality that justifies the extra power and effort required to control their locomotion as explained in Siegwart and Nourbakhsh (2004). Therefore, legged robots may have favorable characteristics for obtaining flexible and robust motion, but suffer of some drawbacks, such as energy consumption, stability problems and locomotion speed as discussed in Figliolini and Rea (2007).

The focus of this study is to present an experimental setup conceived and realized at the University of Cassino and Southern Lazio regarding to the design and implementation of a hybrid mobile system able to explore sites with limited accessibility. This mobile robot will be equipped by instruments, such as a thermal imaging camera, cameras and other sensors. These devices will be connected with a PC in order to provide material information of the data collected.

To date the system it was first tested in the laboratory of University of Cassino and Southern Lazio to verify its engineering feasibility for the task and then it will be used on the real case of a paper mill of Ceprano, a town in the South of Lazio. In this mill a traditional survey has already run, even aided with instruments as thermal imaging camera and the endoscope. It is important to point out that the complete knowledge of the site needs to examine the environment inside the paper mill that is not directly and completely accessible to operators.

BACKGROUND

The theme of the integrated survey is certainly not new, but the updating of some consolidated and revised procedures with newer modes of operation may be considered as innovative. With this regard, the issue of integration is a key element of the "Carta del Rilievo Architettonico [Charter of Architectural Survey, anno]", which expresses the need for a strong interrelation between the different methods, and suggests to consider the survey similar to a multidisciplinary project as described in Novello and Lo Turco, (2014).

The complexity of the work requires that a traditional approach necessary for the philological and geometric/dimensional description is combined with adequate tools for the detection of environmental and material characteristics, together with the aim of conceiving a sustainable recovery plan.

HISTORICAL SURVEY

The first step of this process consist of historical, geometrical and metric analysis. The study of the historical and iconographic documents allows to identify the timing of construction, distinguishing the different phases, expansions or modifications. In particular, it is important to distinguish and characterize:

1. The number of cores forming the whole aggregate, their different dimension and structural characteristics: e.g. the typological system, masonry walls, horizontal elements like barrel or groin vaults, the set of warehouses made of reinforced concrete and stainless trusses;
2. The location and the characteristics of the most important components of the brownfield, like for instance the hydraulic mill for the energy production which can be nowadays recovered for the production of green energy;

Then the geometrical and metric analysis must be obtained by means of a relief of all parts and with a post processing of data with 3D graphic models. This phase covers the metric/structural part of the survey, and provides indications on the size, geometry and compactness of each part.

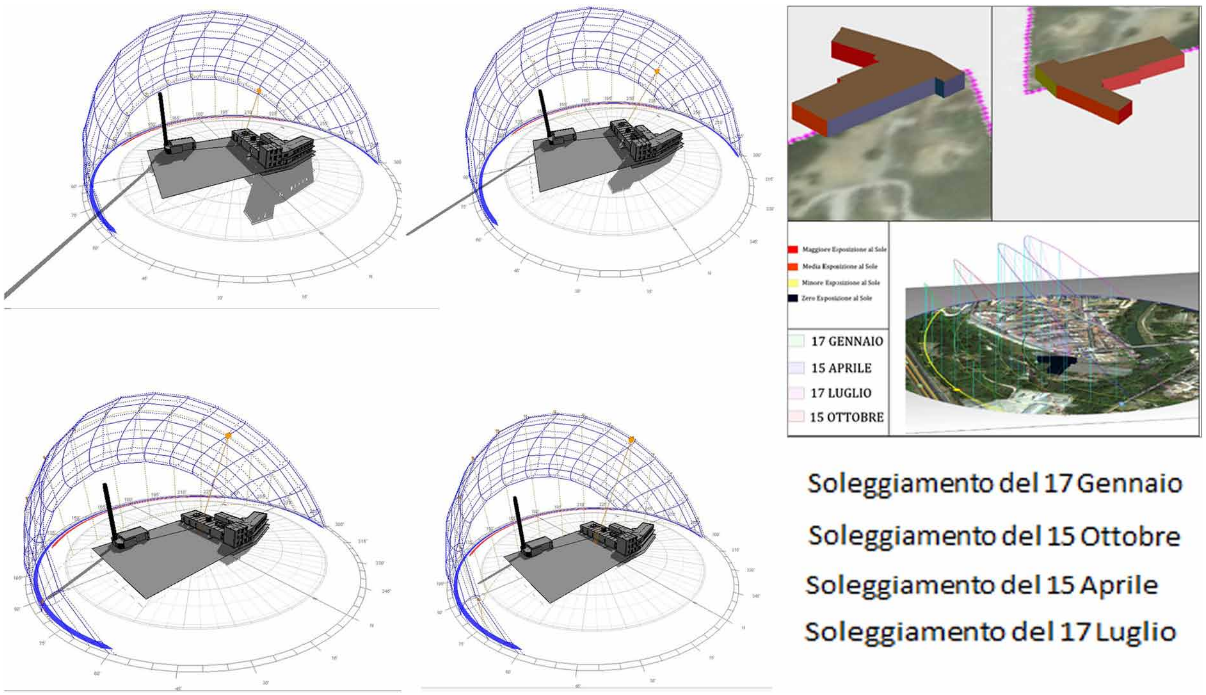
Geometric Survey: The subsequent step needs the recourse to another discipline, the thermodynamics. In order to obtain the required data for the energy audit, a procedure based on the following steps needs to be set up:

1. Quantification of the building shape: the thermal response of the building strictly depends on the surface to volume ratio (less energy is required to heat and cool more compact buildings);
2. Study of the building orientation and sun exposure as it influences the quantity of energy received from the sun; the interaction between building and wind also affects the daylight design;
3. Evaluation of the rooms distribution: the temperature difference between the south-facing and north-facing rooms can promote natural ventilation in summer, improving indoor comfort and reducing the use of air-conditioning systems.

Analysis of Materials: The analysis of the building envelope is aimed to distinguish opaque (e.g. masonry) from glazed (windows) surfaces. In fact, the thermal, hygrometric and acoustic properties, the durability with time (maintenance), the sustainability and strength depend on the material forming the building envelope. All these aspects are key indicators to improve the energy performance of the building. For this analysis it is convenient to build a 3D model (Autocad ®) and to link it with a software performing solar analyses. For the studied case, this analysis has been performed for the four most significant months (January, April, July and October) with reference to the average monthly maximum direct and diffuse solar radiation. As a result, the location of the mill is able to promote the thermal solar contribution through its extensive glazed surface on the north side since it respects the principle of the equisolar axis (Figure 2).

This phase provides also the data required for the third step, i.e. the distinction of the glazed and opaque surfaces of the building. This step, apparently simple, is indeed rather complex as a thermal characterization of the different elements is compulsory. The software currently used for the energy balance analysis requires the input of data on all the elements forming the building and, in particular the dimensional characteristics and thermal and physical properties of the materials. Therefore, it was necessary to detect all the elements, roof, windows and walls. For this purpose, the entire factory was subdivided into four blocks and different analysis sectors were identified for each block. The survey provides a

Figure 2. Paper mill of Ceprano (Italy). Analysis of solar radiation for the four most significant months (January, April, July and October) with reference to the average monthly maximum direct and diffuse solar radiation.

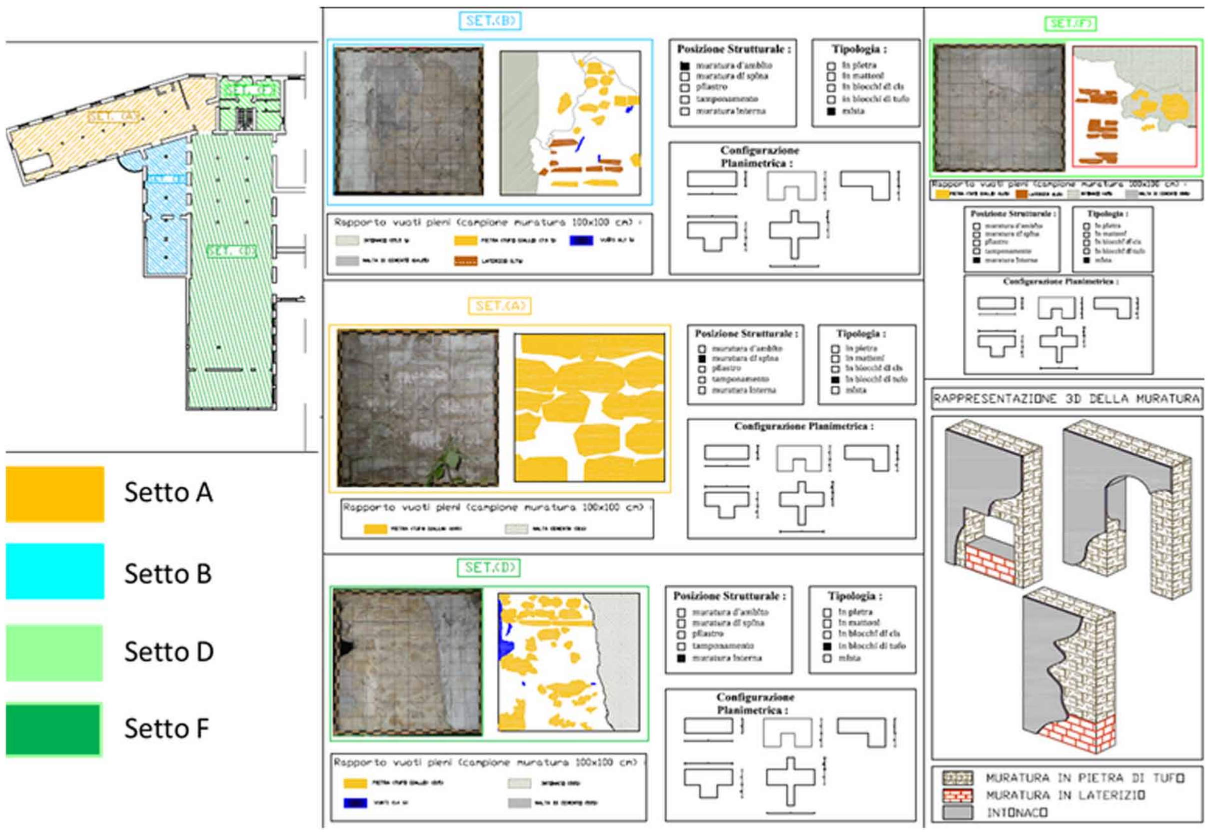


simplified and comprehensive description of the necessary data. For the analysis of masonry elements the procedure consisted in the indication of the different textures and material characteristics of masonry units, which was possible by means of specific tools. Starting from a traditional detection procedure of a 1 m^2 panel subdivided into a 10 cm x 10 cm mesh, obtained with an orthorectified image, nondestructive tests with Infrared camera have been performed (figure 3).

The thermographic measurement is based on the measurement of infrared radiation (heat intensity) emitted by a body shot in natural light. The thermal imaging camera provides images in the infrared frequency band, not visible to the human eye, and thus allows to see the different levels of thermal energy emitted from an object. Greater infrared emitted radiation correspond to greater temperatures of the object. This kind of measurement gives a thermal image of the object, i.e. a map in "false color", which represents the "thermal state" of the investigated surfaces (the processing software associates a different color to each surface temperature). The color, from dark purple to yellow, varies as function of the temperature range chosen by the operator according to the change in internal/external temperature of the article that is being investigated.

These color changes as function of the chemical composition of the materials forming the objects, but also highlights the presence of thermal bridges, including those produced by infiltration of water. Applied at larger scale, the thermography provides a diagnosis of buildings as it is able to reveal openings in the walls hidden by the plaster, the entire wall apparatus, the presence of lintels or stone columns, ribs of voulted surfaces (false voult), the degradation associated with detachment of material, biological patinas or infiltration and thermal dispersions.

Figure 3. Paper mill of Ceprano (Italy). Analysis of characteristic of walls.



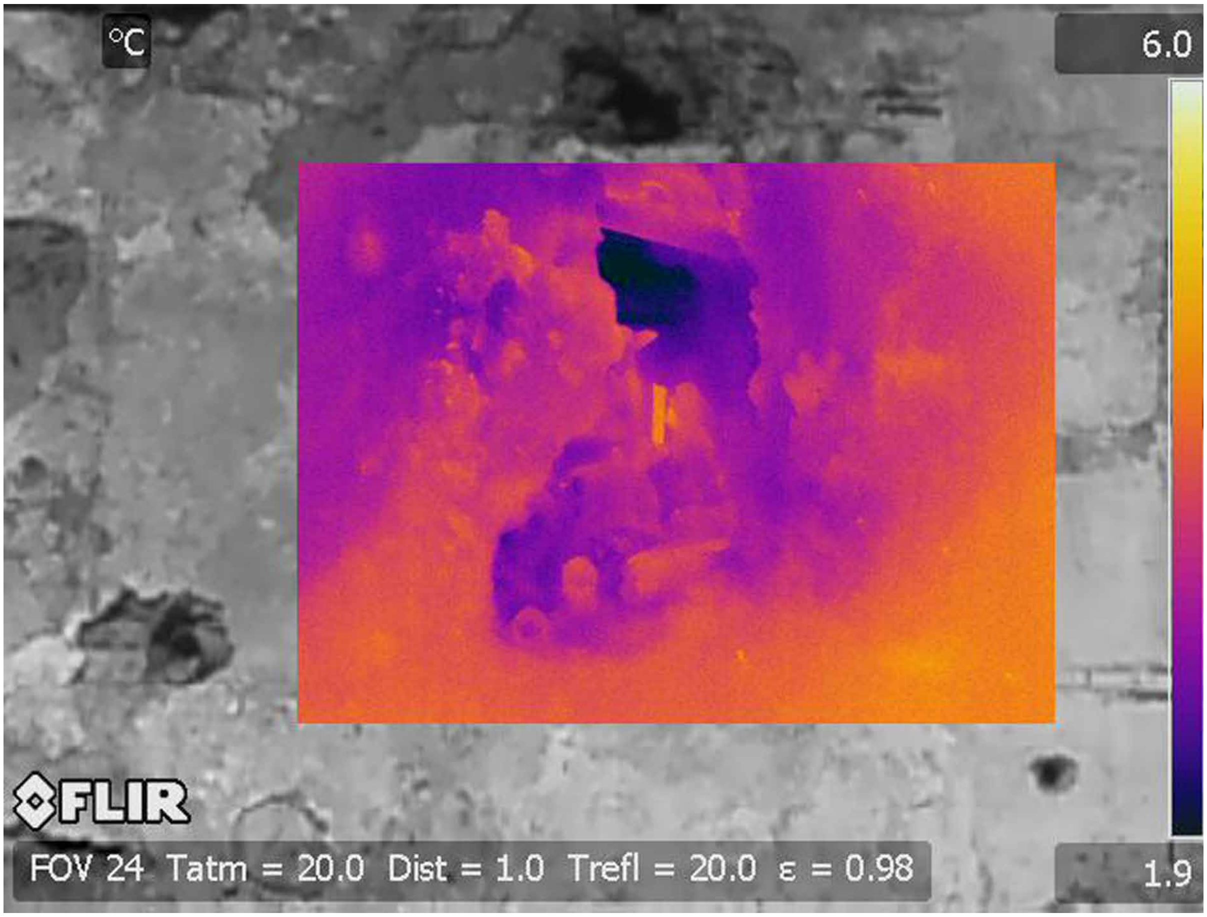
The test is non-invasive and results can be imported into image/alphanumeric data management tools such as GIS. Despite the result of the thermal investigation is qualitative and enclosed in a raster image some quantitative analysis can be attempted with the aid of an information system (Figure 4).

The Geographical Information Systems generally process vector images. Nevertheless, the system is also able to identify the pixels of raster images, to georeference the center of each pixel and to quantify the contained colorimetric and Boolean information. In particular. this goal can be achieved by a algebraical operation where the mother image is subtracted and pixels with a given RGB (Red-Green-Blue) value, or range of values are recognized as corresponding to particular materials. In this way, a new image containing only the extrapolation of the requested data is generated. The GIS systems have also another interesting application, called MAP-Algebra which operates algebraic and mathematical functions right on the pixels and produces new raster maps as described in Meschini and Pelliccio (2013).

On the basis of the above considerations, the thermograms can be imported into ArcMap, where by means of MAP-Algebra, the noise of the camera can be eliminated from the images and the wall texture, or structural elements can be returned. Finally, the obtained raster image can be “smeared” on the 3D model of the building organism and read with ARC-Scene.

In addition to the thermal imaging, some dividing walls can be analyzed with endoscopes, since the wall stratigraphy was extremely complex. A number of $\phi = 20$ mm holes were initially made

Figure 4. Thermographic analysis: example of nondestructive investigation technique.



from the external façade for a depth of about 1 m and then they were inspected with the endoscope as reported in Pelliccio et al. (2014).

The analysis of the output data allowed a graphic reconstruction of the stratigraphy and compactness of the analyzed masonry elements. The thermographic analysis, which is a nondestructive investigation technique, as described in Giovinco et al. (2012), is widely used for the diagnosis of buildings diseases (infiltration, moisture, moulds, etc.). In the present case the Infrared thermograms allow the identification of the different materials covered by the plaster: wood or stone lintels, roof structural elements. The post-processing of these data gave maps of temperature, humidity and thermal bridges, some information on characteristics of walls. Finally, the collected and post-processed data could be used also to identify the current energy performance class of the building.

Mechatronic Survey: The analysis of the different cases shown in the literature reveals the need to identify other tools for the survey of structures whose size is too small to let operators access. A ground vehicle can be the key solution. It can be remotely managed by an operator to overcome obstacles and allow the transportation of equipment such as a thermal imaging camera. The attention is then directed towards a mechatronic system designed for this purpose.

Hybrid systems are a rather new type of mobile robots that were developed to exploit the terrain adaptability of legs in rough terrain and simpler control as well as high speed related with wheels rather than their counterparts. They can be classified into two main groups: in the first one legs (or sub-tracks) and wheels (tracks) act independently and articulated legs (sub-tracks) can provide traction for the obstacle-climbing when wheels (tracks) cannot Therefore legs and wheels are actuated by motors. Alternatively, the wheels can be purely passive (i.e. with no actuation system) and they are used only to stabilize the system. The basic idea of the first group of hybrid mobile robots was used for example by the authors Guccione and Muscato (2003), Ottaviano et al. (2011), Gonzalez Rodriguez et al. (2011), in which wheels were passive. Innovative prototypes of wheelchairs capable of climbing stairs have Wellman et al. (1995) and Gonzalez et al. (2009). A prototype of stair-climbing robot was proposed in the work Han (2008). The solution dealing with independent sub-track was adopted by QUINCE robot developed by a research group from Chiba Institute of Technology and Tohoku University to be used to collect rescue information in case of Chemical, Biological, Radiological and Nuclear disasters, like Fukushima nuclear plant, as proposed in Nagatani et al. (2013) and Nagatani et al. (2011). Another relevant example is the Packbot described in the works Yamauchi (2004), and Yamauchi and Rudakevych (2004), which was developed and commercialized by IRobot, USA, for rescue and search application. It was successfully used into the damaged Fukushima nuclear plant after the 2011 Tōhoku earthquake and tsunami.

The second type of hybrid robots deals with wheels (or tracks) installed on each leg end tip. In particular, the articulated leg is efficiently used to overcome slopes or obstacles that cannot be surpassed with tracks or wheels only. The design solution using wheels at leg tips was adopted for example by Grand et al. (2004), Aarnio et al. (2004), Hirose and Takeuchi (2004), and Siegwart et al. (2002).

Therefore, by analyzing those types of mobile robots the most promising ones seem to be the first type of the hybrid solutions for locomotion since it is robust, combines advantages of the other types of robots and it is well suited for a large variety of scenarios, indoor and outdoor environment, with obstacles, slopes, stairs, steps, like the scenario understudy. In addition, most of legged or wheeled robots developed in literature, cannot be easily adapted to environments designed specifically for human beings. If such devices have to be used at industrial sites, they will require special arrangements such as ramps to allow them to move around. Therefore, it could be desirable to have robots capable to surpass obstacles and adapt to the environment. Recent prototypes of hybrid robots using sub-tracks have been successfully used in such environment as explained in Nagatani et al. (2013) and Yamauchi (2004), demonstrating the high adaptability of such systems.

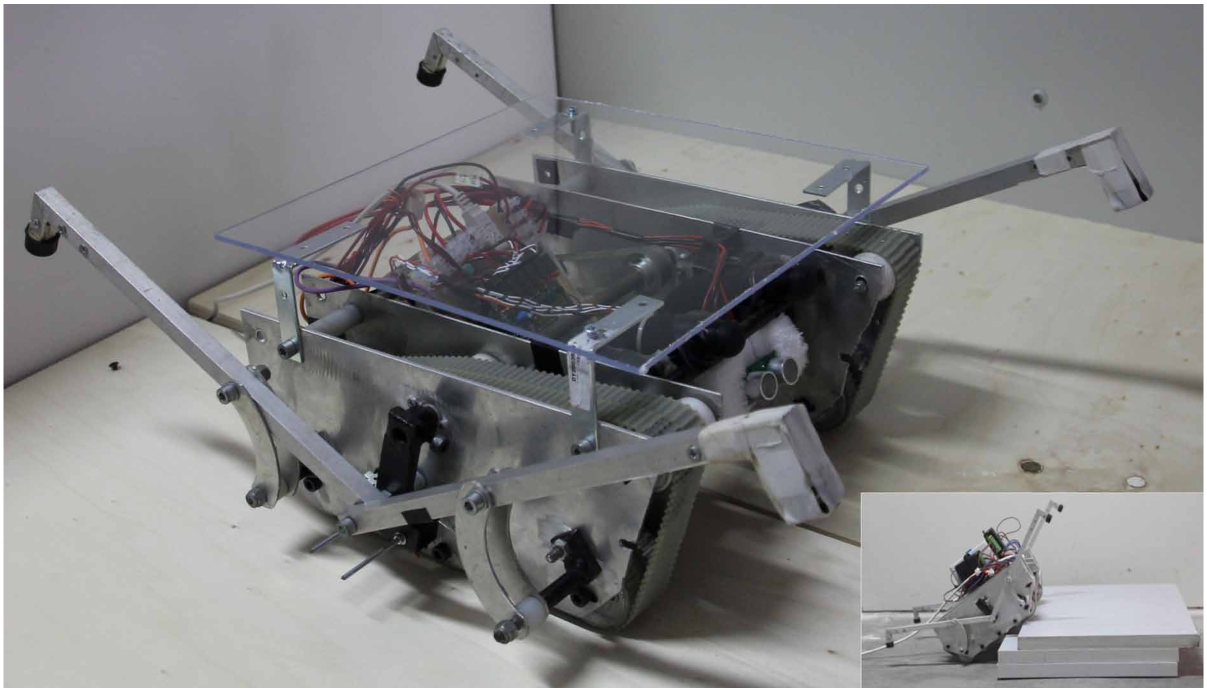
From the above-mentioned considerations it can be concluded that the technology to be used in hazardous environments, which may be dangerous and/or inaccessible to humans, are hybrid mobile robots. Therefore, we propose in this context the application of mechatronics technology to aid this complex survey.

A PROPOSAL FOR A HYBRID ROVER TO USE FOR A COMPLEX SURVEY

A prototype of novel concept hybrid robot was designed at the University of Cassino and Southern Lazio to be used in industrial sites, especially in hazardous areas such as nuclear power plants or for surveillance and rescue operations for military and civil tasks. It was presented in Ottaviano et al. (2014) and it can be conveniently used specifically in abandoned places, like brownfields thanks to its good adaptability of scenarios with obstacles.

The design concept of the THROOO (Tracked Hybrid Rover to Overpass Obstacles) prototype is

Figure 5. The hybrid rover THROO presented in Ottaviano et al. (2014)



shown in (Figure 5) with low-cost easy-operation features. In order to obtain these characteristics for a mobile robot the following characteristics have been considered for its mechatronic design: compactness, light weight, reduced number of DOFs to simplify control of the mechatronic system and with robust mechanical design. The load capacity is another important issue, since the mechatronic system is implemented to carry devices or measurement systems.

The hybrid rover has been designed with tracks and legs for an efficient locomotion with the ability to overcome obstacles. Among several solutions dealing with robotic legs, a linkage having 1-DOF only is used for keeping the basic characteristics of the overall design, that are low-cost and easy-in-use, in fact the reduction of the number of DOfs leads to a complexity reduction in manufacturing and control. The solution of the proposed robot deals with tracks and legs, indeed the contact with the obstacle during the climbing is obtained by the leg endpoint, instead of a sub-track or track.

As previously described, the operating environment of the prototype consists of regular floors with steps and ramps (typically an environment of industrial site). Nevertheless, the prototype has been tested in rough terrain with obstacles demonstrating a good capability of surpassing obstacles and good stability preventing overthrowing.

The robot has 3 DOFs, two of them are used for the track giving the ability of straight motion and turning ability. An additional motor is used to actuate the four legs, more specifically each couple of rear and front legs share the same cranck link and work providing a mirror trajectory of the leg end-point. This design solution allows a very well adaptation to step and obstacle climbing.

The prototype size is 550 x 400 x 200mm, all mechanical components are made of aluminum and actuation and transmission systems are of commercial type. The overall mass of the prototype is 4.5 kg (batteries not included). It is worth to note that its dimensions vary according to the legs' configuration, maximum values are given in this context. The actuation system is composed by 2 DC motors for the track with following features: power supply of 24V, max torque of 5Nm, nominal power of 3.9W. The motor used to actuate the legs has a power supply of 24V, max torque of 12Nm, nominal power of 24W.

In addition, the top of the robot chassis has been left free of any mechanical component to get a compact design and to allow the installation of suitable equipment for data acquisition.

The Task

Five main issues may be recognized for the task of brownfields exploration understudy: 1) access to the site, 2) in-site mobility, 3) collection and data processing for modeling and other scientific objectives, 3) power, and 5) communication. It has to be mentioned that recently drones / aerial vehicles have started to be used for exploration and data collection in indoor and outdoor environments. They are becoming widely accepted and used for a large number of applications Li et al. (2011). Nevertheless, in this context we have chosen not to use this kind of technology due to their main disadvantage that is related to relatively short time autonomy in term of power supply and difficultly to access in sites with limited height.

The first two issues, namely access and in-site mobility, can be conveniently managed by considering the hybrid locomotion structure to carry equipment, as described in the previous Section. The combination of tracks and legs allows the robot a great stability, robustness, and autonomy as referring to power supply. The prototype can carry the battery for propulsion together with suitable data acquisition. More specifically, the robot is expected to traverse bumps, ramps, slopes, and rubble. The THROO robot already had the capability to satisfy the above requirements because it was designed for practical use in search and rescue missions, details can be found in Ottaviano et al. (2014). Therefore, the details of its mobility will not be covered in this context.

The robot is equipped with electrical motors that requires power. Two solutions can be adopted, namely the use of batteries installed on board or wired-only power supply. In the case of study, in which the robot has to deal with very variable environment with the risk of damage or loss of the equipment, it is desirable to use both technologies, standard wired-only powering and batteries on board when the wired connection is lost and we need to recover the robot.

As referring to the collection and data processing, we have equipped the hybrid rover with a thermal imaging camera, a camera to perform analysis of the environment, as shown in Figure 6.

In addition, for future improvements of the mechatronic system 3D mapping can be considered to be a very good tool for understanding the environment. Therefore, some modifications to the sensors were required in order to facilitate the mission.

In order to assess the pose of the hybrid rover inside the brownfields and facilitate the maneuverability the robot can be equipped by sensors, like inertial measurement unit, to understand the pose of the robot, and cameras that are used for understanding the surrounding environment. The above mentioned sensors are the minimum requirement for exploration in these abandoned environments. To obtain useful images when using the cameras in a dark environment, lighting is very important. LED array lights can be conveniently mounted in the front and at the back of the rover, along with additional batteries.

It is worth to mention that in this initial set-up the thermal imaging camera was mounted as fixed on the chassis of the hybrid rover. Therefore, at this first stage data acquisition can be performed by fixed angle only. Future development of the system is to provide a base with a rotational DOF to provide the camera by swing motion.

Communication between the master and the rover in standard exploration missions can be performed by wireless connection. The prototype of THROO was remote controlled by an opera-

Figure 6. The hybrid rover THROO equipped with thermal imaging camera and suitable sensors

tor (master) who is placed in a safe area outside the brownfields for safety reasons due to real or perceived environmental contamination risks. Unfortunately, the target environment may contain thick concrete walls that block gamma rays, making it highly probable that radio communication would also be inhibited. Therefore, the condition of signal reception inside the buildings needed to be checked. In the case of poor reception, a wired-only communication solution would be required to ensure reliable communication during the mission.

FUTURE RESEARCH DIRECTIONS

Current trends suggest the possibility of using aerial systems, such as drones, when the site can be much more conveniently explored by air rather than ground and when the load to carry is miniaturized equipment. For the case understudy, it is recognized that the use of drones for the mobility inside brownfields may be not successful due to accessibility problems and load to carry. Therefore, ground vehicles may represent the key solution to access those sites. Recently, the join group of Cassino composed by engineers and architects, is exploring the possibility of developing a novel mobile system for a completely new application dealing with 3D laser range scanner. The goal of future applied research is to realize automatic acquisition by laser scanner with the aid of suitable mechatronics technology.

CONCLUSION

As a matter of fact, survey and restoration of abandoned sites have become of great importance in the last decades. The brownfields are amongst the most relevant historical evidences of the socio-economic, political, architectural and urban heritage of populations, therefore, they represent an excellent example of a complex survey that requires multidisciplinary approach. Since the rehabilitation of these sites need a deep and accurate knowledge of the environment and current deterioration, it is also important to develop and study mechatronic and digital technologies to be specifically used in this context. The use of ground vehicles can be considered convenient for such applications in which autonomy and heavy load carriage are first requirements. Currently, a prototype of hybrid rover has been tested at University of Cassino and Southern Lazio for laboratory experiments. Future developments of this application regard the use of the described mechatronic and digital technologies in abandoned sites to perform measurements and analysis of the environment in site.

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KEY TERMS AND DEFINITIONS

Brownfield: In urban planning, a brownfield site (or simply a brownfield) is land previously used or industrial purposes or some commercial uses. The land may be contaminated by low concentrations of hazardous waste or pollution, and has the potential to be reused once it is cleaned up. In the European context a working group, named CLARINET, defines brownfields like a "sites that have been affected by the former uses of the site and the surrounding land; are derelict or underused; have real or perceived contamination problems; are mainly in developed urban areas; require intervention to bring them back to beneficial use". In general there are three different types of abandoned industrial area: uncontaminated area, contaminated area, potentially contaminated area. Land that is more severely contaminated and has high concentrations of hazardous waste or pollution, such as a Superfundsite, does not fall under the brownfield classification. Actually the brownfileds represent urban "voids" and above all a source of degradation.

Geographic Information System (GIS): GIS is a system that integrates hardware, software, and data for capturing, storing, managing, analyzing, and displaying all forms of geographically referenced information. GIS allows to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

Hybrid Robot: Hybrid mobile robots are automatic systems that use a combination of wheels (or tracks) and legs in different configurations to perform locomotion.

Industrial Archeology: Industrial archeology is a branch of archeology that studies applying an interdisciplinary approach, all the evidence related to the industrialization process from its very beginning in order to learn more about the history of the past and present industry. These evidences are: the places of production processes and technologies, the archaeological traces generated by these means and machinery by which these processes are implemented, the products of these processes, all the written sources related to them, the iconographic sources, oral, etc.. The period studied industrial archeology is that from the second half of the 18th century to the present day. The industrial archeology relies on the application of many disciplines for its study, including: archeology, architecture, engineering, technology, planning.

Mechatronic System: A Mechatronics system includes a combination of mechanical, electrical, telecommunications, control and computer science technologies. Mechatronics is a multidisciplinary field of engineering. The word "Mechatronics" was originally "Japanese-English" word created by Mr. Tetsuro Mori, who was an engineer of Yaskawa Electric Corporation and the word "Mechatronics" was registered as Trademark by the company in Japan with the registration number of "46-32714" in 1971. However afterward, the company released the right of using the word to public, and the word "Mechatronics" didn't only stay in Japan, but also introduced as a native English word. Nowadays, the word is translated in each language and the word is considered as an essential term for industry.

Mobile Robot: A mobile robot is an automatic system that is capable of locomotion. Mobile robots have the capability to move around in their environment and are not fixed to one physical location. Mobile robot may have wheels, tracks, legs or a combination of them.

Survey: In Architecture is the science determining fully understanding the metrical, geometrical and historical aspects of an architectural work, penetrating the deepest and most hidden nature of an architectural organism, bringing to light the historical events of which it has been protagonist, original form and subsequent transformations over different eras, and providing us with full graphical imagery.

Technical Representation: Technical drawing is the act and discipline of composing plans that visually communicate how something functions or is to be constructed. Technical drawing is essential for communicating ideas in industry and engineering also for a project of survey. To make the drawings easier to understand, people use familiar symbols, perspectives, units of measurement, notation systems, visual styles, and page layout. Together, such conventions constitute avisual language, and help to ensure that the drawing is unambiguous and relatively easy to understand.

Thermography: The thermography is a technique for non-destructive analysis which is based on the acquisition of images in the infrared. Thermographic cameras detect radiation in the infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 μm) and produce images of that radiation, called thermograms. Since infrared radiation is emitted by all objects above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination. The thermographic measurement is based on the measurement of infrared radiation (heat intensity) emitted by a body shot in natural light; it has been shown, in fact, a fundamental support for the knowledge also of structural aspect of architectural sites. This kind of measurement gives a thermal image of the object, or a map in "false color", which represents the "thermal state" of the surfaces investigated because the process associates to each surface temperature in a different color.