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Experiencing the Sights, Smells, Sounds, and Climate of Southern Italy in VR

Vito M. Manghisi, Michele Fiorentino, Michele Gattullo, Antonio Boccaccio, Vitoantonio Bevilacqua, Giuseppe L. Cascella, Michele Dassisti and Antonio E. Uva
Polytechnic University of Bari

In many regions tourism is an important, if not the most important, driver for employment. As long-distance travel has become more affordable, such regions have increasingly competed against one another to attract tourists. Historically, countries and regions have used TV and magazines advertisements to increase tourism. As VR devices become less expensive and more commonplace, VR promotions that showcase a region's various attractions will have greater impact.

This article explores what it takes to make interactive computer graphics and VR attractive as a promotional vehicle, from the points of view of the tourism agencies and the tourists themselves. Specifically, in response to a call from local authorities seeking to increase the tourism appeal of the Apulia region in southern Italy, we proposed an alternative approach to traditional tourism marketing and advertising efforts—a physical stand containing only videos looping on a screen, leaflets, and local personnel. Our ambition was to exploit current VR and human-machine interface (HMI) technologies to design and provide an interactive, innovative, and attractive user experience that we call the Multisensory Apulia Touristic Experience (MATE).

Why the Apulia Region Needs VR

Apulia is a charming region located in the far southeast area of Italy. A narrow peninsula referred as the “heel” of Italy’s “boot,” it is surrounded by sea and has with a population of about 4 million inhabitants. Thanks to its extraordinary culture, history, and natural landscapes, this land has great tourism potential. However, Apulia’s economy is weak compared to the rest of Italy (17.70 Euros gross domestic product [GDP] per inhabitant versus 32.20 Euros in northwest Italy in 2014).¹ Regional authorities have recently promoted tourists activities and obtained positive results: a 4.5 percent increase in Italian tourists and a 13 percent increase in international visitors in 2016.

Despite this success, the region is still far less known than other Italian destinations. The local authorities are exploring new ways to promote it and have agreed to invest in application-oriented VR research.

Therefore, our main objective is to design and develop an innovative system able to share Apulia’s cultural heritage in an engaging and multisensory experience. We began by implementing a test case that follows a scenic trip through the Apulia’s Murgia territory to showcase its hidden cultural treasures, local scents, and mild climate.

Inspirations and Ambitions

Studies have shown that virtual environment (VE) applications can effectively promote tourism.^{2,3} These applications create a sense of presence, and this sense of “being there” is known to be the result of the two psychological states: immersion and involvement.⁴ Related literature has proven that the sense of presence in VEs grows with the number of senses engaged^{5–7} and with the level of agreement among them.

We drew our inspiration from Sensorama,⁸ a multisensory VE system invented in the 1960s by Mort Heilig (see Figure 1). Sensorama is a motorbike simulator that allows the user to sit on a real saddle and experience an interactive ride with stereoscopic vision, 3D sound, vibrations, wind, and smells. This

extremely innovative idea failed when it was developed because of the technical immaturity of the technologies involved and financial issues.

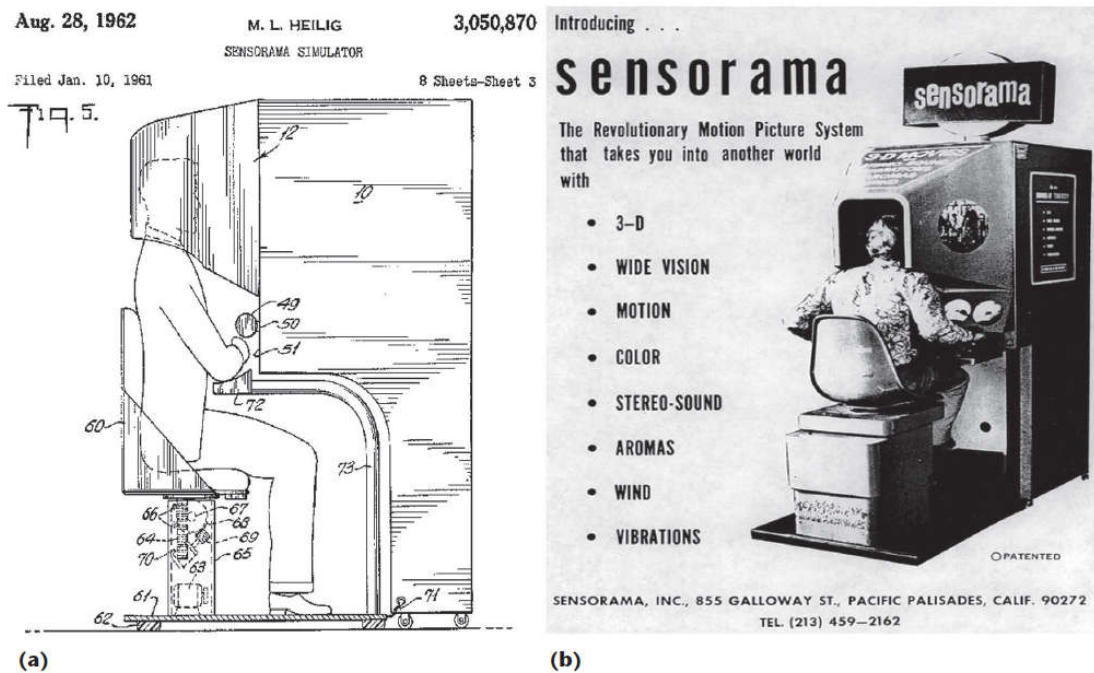


Figure 1. Sensorama: (a) illustration from the patent (US 3050870) by Morton Heilig and (b) the product advertisement from the 1960s. (Courtesy of Scott Fisher's Telepresence)

As VR systems evolved, the number of senses embraced by VEs increased. The Multimodal Floor⁹ produces a virtual walk in which users walk on a real mobile floor that mimics a natural surface, such as snow or ice, with visual, audio, and haptic feedback. Yasushi Ikei and his colleagues later developed the FiveStar,¹⁰ an interactive personal display consisting of a stereo visual, 3D audio, haptic/tactile, wind/scent, and vestibular display. Jorge Freitas and his colleagues proposed a multisensory management and visualization system for multisensory content.¹¹ It provides visual, auditory, haptic, and olfactory feedback as well as an interface that lets users author the virtual experience by defining the timestamps that indicate when to stimulate each sense.

MATE Design

We designed MATE as a virtual tour in collaboration with industrial partners and local tourism authorities, who played an active part in defining the system's requirements and features. One of the main design requests was to build a mobile platform that could be relocated to various promotional events all over Europe, such as public exhibitions and fairs. Also, to minimize the operating costs, the system needed to be simple enough that it could be run by a small number of unqualified staff.

Therefore, we installed the system inside a 20-foot container that is divided into two main areas: the control room and the user experience zone (see Figure 2). The control room hosts the main PC, the ambient control unit (ACU), and the power management. The user experience area is about 12 square meters and can host four to six visitors simultaneously.

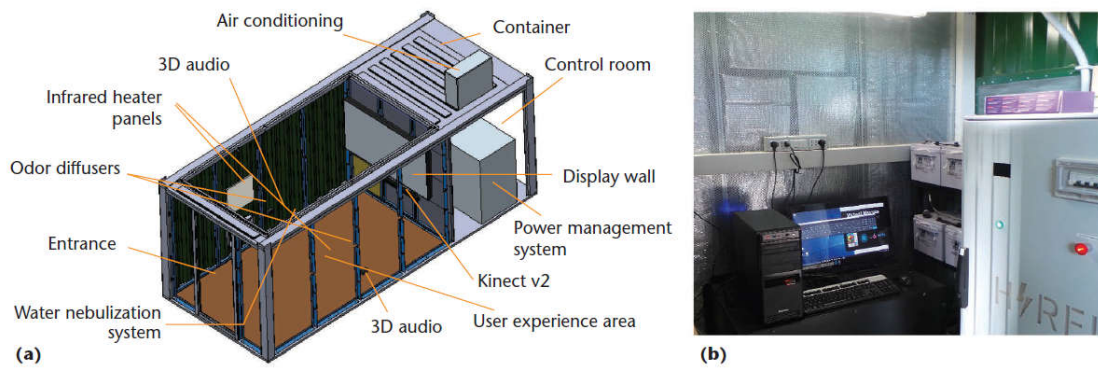


Figure 2. Multisensory Apulia Touristic Experience (MATE) mobile container configuration: (a) installed systems in the user experience zone and the control room and (b) a photo of the control room.

To allow MATE visitors to see, hear, feel, and smell the real Apulia, we asked ourselves what could be added to the visual feed to deliver a unique, surprising experience. Our goal was to trigger a memorable event for the users.

To do so, MATE enhances the user experience by providing olfactory and climatic stimuli. As users take the tour and enter a new scene, the humidity, lighting, and ambient scents change accordingly. To convey the olfactory stimuli, we used an array of odor diffusers using the Solid Fragrance Release (SFR) system from the Oikos Fragrances. Odors are delivered using a ventilation fan in the mobile container.

Unlike traditional technologies based on evaporation, combustion, or spraying processes, the diffusion is based on solid-state activation. This process lets us modulate and control the release of the olfactory note, keeping the original qualitative characteristics of the fragrance while maintaining the transmission of the desired olfactory message.

To control the climate conditions, we used an oversized air conditioning system (Daikin SARARA FTXZ50N/RXZ50N KLIC-DD KNX FTXZ50NV1B, 5.8 kW cooling, 9.2 kW max heating power), a 400 W infrared heating panel (Infrapower IPW400), a water nebulization system, and an aspirator (EVVOK1 mod. 250 by Erre.Gi. srl). The climate condition system allows for rapid temperature and humidity changes, ranging from 15°C to 30°C and from 40 to 60 percent, respectively. We implemented the water nebulization system to simulate rain and fog using six mini-drop emitters mounted on the ceiling and an 800 W pump. The aspirator (with a flow rate of 500 cubic meters per hour) rapidly cleans the air to allow for fast scent and climate changes. Furthermore, an intensity and RGB-color-controlled lighting system provides variable lighting conditions.

For the visual stimuli, we chose 2D rather than 3D footage for the virtual tour. There were many reasons for this choice, but the most important was to avoid the cyber-sickness effect.¹² Cyber-sickness can cause discomfort and even vertigo when the users are standing in a restricted environment, which could visitors to fall and/or other potentially dangerous situations. In our tests, we encountered a high rate of cyber-sickness among casual users with short or no training time and when the point of view could not be controlled individually. As a second consideration, the added value enabled by 3D depth perception is limited in virtual tours consisting of mostly landscapes and confined places.

Other solutions, such as the currently available autostereoscopic displays, may diminish the visual quality. In addition, 3D goggles or head-mounted displays (HMDs) lead to practical problems, such as the time to fit and adjust the devices (especially if the users wear glasses), eye distance calibration, device sensitivity to the moisture introduced by our climate condition system, risk of theft, hygiene, and user isolation.

Ultimately, we mounted a professional 85-inch ultra-high definition (UHD) LED monitor (Samsung QM85D) to the wall at one end of the visitor area. The screen is connected to a desktop PC hidden in the control room and is able to render 4K resolution tours at approximately 120 Hz and to generate 3D stereo sound. The audio is provided by a 5.1 channel surround system (Logitech Z906).

Because MATE must work with people of all ages who are unfamiliar with VR, and even IT technology in general, the user interface design must also be easy to use with minimal training. We wanted to provide a

shared group experience for up to six users, in accordance to the communal, familial experience of the visiting site. For reasons similar to those for the goggles (theft and hygiene), we decided not to use physical controllers such as a joystick, glove, or mouse.

We implemented a natural gesture-based interface (see Figure 3). The gesture-detection system is based on the Microsoft Kinect v2 RGB-D, mounted under the screen. Users' gestures are detected by proper heuristics using as input the joint data obtained from the Microsoft skeleton-tracking. The interaction is controlled by the "dominant user," who is detected among the group of visitors as the closest to the sensor.

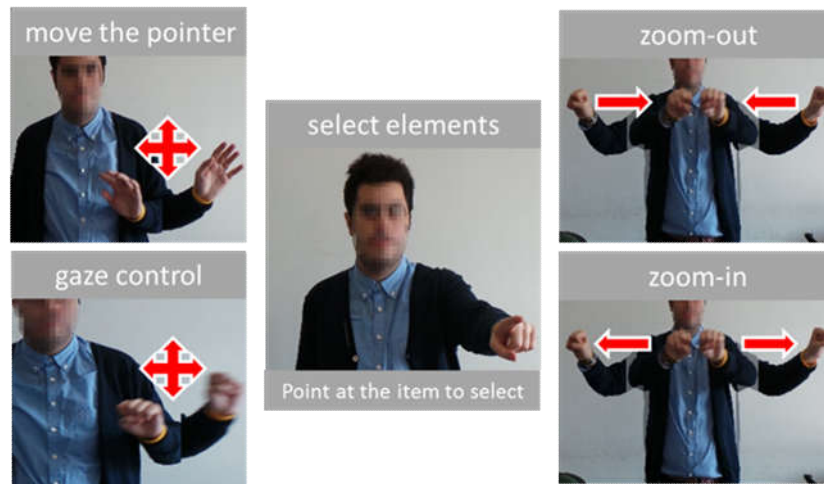


Figure 3. MATE gesture-based interface controls. The user closest to the sensor can navigate the virtual tour with five possible commands: gaze direction control, zoom in, zoom out, select hotspot/item, and move to the point of interest.

The users can interact one at a time and take the lead by simply moving forward. To ensure a playful and easy-to-learn experience, we limited the interface to five possible commands: gaze direction control, zoom in, zoom out, select hotspot/item, and move to the point of interest. Our interface is bimanual so it can be operated by both right- and left-handed users. The system detects the "control hand" in real time as the one kept at the highest height. Users can switch their control hand in real time, which has the advantage of unconsciously reducing fatigue and the "gorilla arm effect."¹³

The Apulia tour consists of a set of scenes, each of which is a spherical image of the real site annotated with multimedia content and linked to the others by hotspots. Using on the five gesture controls, MATE visitors can interactively navigate 360-degree 2D images during their virtual tour experience.

Authoring System

The MATE system integrates three modules: the display system, the user interface, and the environmental module (see Figure 4). We used the krpano suite (www.krpano.com) as the main framework for implementing the tour. Each virtual scene includes krpano basic functionalities, such as multimedia content (videos and sounds) and static or animated hotspots (active areas to trigger tour events).

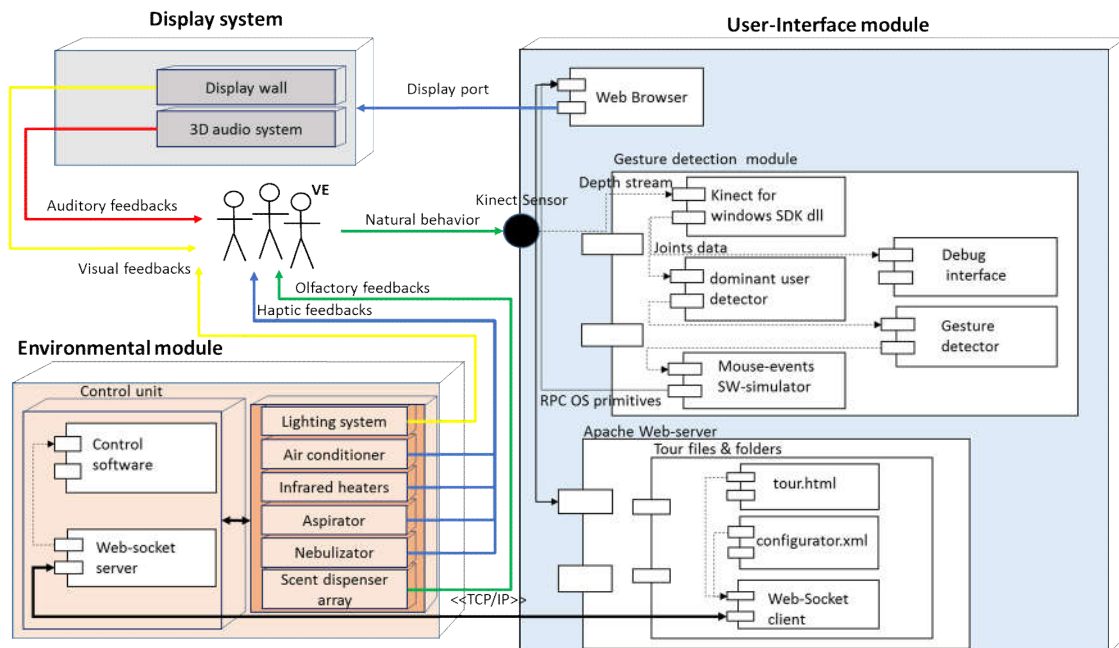


Figure 4. Functional scheme of the MATE system. The three modules include the display system, the user interface, and the environmental module.

One of our main successes was the design of the MATE authoring methodology and a set of utility applications that allow users without programming expertise (such as historians and marketing personnel) to create tours autonomously.

The process starts with a high-level description of the tour that determines the objectives and the targeted users. The next step is media creation and processing, where image and video processing lead to the final digital media content. To help users create spherical scenes, we developed custom scripts using the ImageMagick library (www.imagemagick.org). They can start from different media types: static images (such as overlapped panorama pictures, 360-degree spherical images, or single flat images) and videos (including 360-degree videos). Traditional 2D images and videos can be visualized in a scene of the tour inside pop-up windows, and the author can adjust the sizes. This feature was required because some of the existing media could not be recaptured specifically for this project.

The next step is to define the climate and smell control with a custom XML file using a visual editor. In the final phase, the author links the scenes using hotspots and sets up the transition effects. Smooth transitions are important both to reduce cyber-sickness and improve the overall user experience. An Apache server running on the desktop PC hosts the virtual tour.

All the ambient condition changes are triggered by the tour events and are controlled by a dedicated XML configuration file. The file stores all the parameter settings related to the scene's climate conditions and scents. To enable communication between the tour and the environmental control system, we developed a custom JavaScript function that implements a WebSocket client. It is embedded in the HTML pages of the tour and exchanges messages with a WebSocket server that runs on the environmental control side in a climate control unit (developed by the authors). For each scene transition event, the client sends a message with a payload containing information related to the new scene and the dominant user's position. The control unit decodes the payload and delivers it to the specific actuators of the environmental changes. To guarantee coherence among stimuli, we calibrated the visual transition between scenes by using automatic timers to anticipate the emissions that have higher latency (such as odors and climate changes).

Case Study: The Murgia Experience

Apulia offers a range of attractions, from the unique and remarkable trulli in Alberobello and the

magnificent Castel del Monte in Andria (both UNESCO World Heritage Sites) to the crystal-clear waters surrounding the Tremiti Islands and the outdoor adventures that await in the Murgia National Park. The region is soaked in tradition and folklore, and its food and wine specialties are known all over the world. Our effort was to convey all these experiences to MATE visitors.

In particular, as a test case, we chose the Murgia countryside, which suffers from limited public awareness despite its tourism potential. The tour simulates a trip through the Murgia territory to discover its “hidden treasures” (see Figure 5). The natural landscapes portion of the tour surrounds visitors with typical Apulian scents such as the countryside’s native vegetation: thyme, wild gooseberry, and wild fennel. The Murgia territory’s highest elevation is Monte Caccia, at 679 meters above sea level. The rocks are mostly composed of Cretacic limestone, so that karst landscapes prevail in the area, with doline fields, sinkholes, and caves. The ancient Appian Way, **one of the earliest and strategically most important Roman roads of the ancient republic** //correct?// dating back to 312 B.C., crosses these territories. The tour also shows visitors the Masseria Jesce, an ancient manor farm dating back to the 16th century. Visitors will see the farm’s architectural features and can admire a rock settlement surrounding it, which consists of amphitheater caves, including a frescoed crypt dedicated to the Archangel St. Michael dating from the mid-14th century that contains a deesis (see Figure 5b).

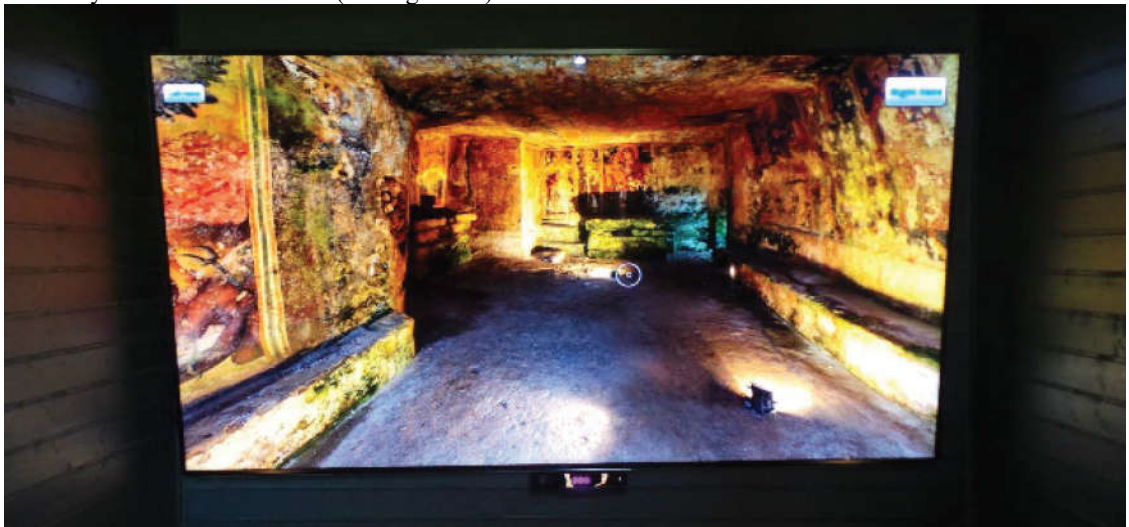


Figure 5. Murgia Experience case study. (a) The tour simulates a trip through the Murgia territory, showing its “hidden treasures,” including (a) natural landscapes (as seen by the user inside MATE in the container) and (b) a frescoed crypt dedicated to the Archangel St. Michael.

Most of the sites included in the tour are normally not accessible to the public for safety and conservation reasons. However, the high-resolution images and display, the possibility to zoom in, and the textual descriptions provide a useful and exciting experience.

During the tour, users also visit to a traditional bakery and experience the production of bread from the Altamura region, with the related scents.

We implemented a simple authoring method to develop the test case scenario of Murgia’s countryside. We then carried out a preliminary within-subject design user test with 16 voluntary participants (average age 28, 80 percent male). We asked them to navigate the virtual tour in two separate sessions (in counterbalanced order): one on a simple desktop PC with a mouse and the other inside MATE. Figure 6 shows a picture from the gesture interaction tests performed in the laboratory.



Figure 6. Laboratory gesture-interaction tests. Participants shown the Murgia Experience case study tour indicated that their enjoyment was significantly higher in the MATE.

At the end, we interviewed users using a questionnaire. Our participants indicated that their enjoyment was significantly higher in the MATE as opposed to using the PC with mouse interface ($p = 0.015$).

Currently, the MATE system is being integrated into a full-scale prototype demonstrator that will be carried all around Europe. Based on our experience and feedback, we think that the use of 360-degree videos can further increase the wow effect and fun factor. Another suggestion from our case study participants was to use source images for the 360-degree panoramas, with as high a resolution as possible, so users can enjoy the zoom-in function to discover new details.

In the future, we plan to evaluate MATE in further tests to measure its usability, enjoyment/engagement, and user satisfaction. We believe that the versatility of MATE's authoring system will make reusable it so other regions can use it for promotions as well.

Acknowledgments

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Vito M. Manghisi is a //PhD student// in the Department of Mechanics, Mathematics, and Management (DMMM) at the Polytechnic University of Bari. Contact him at vitomodesto.manghisi@poliba.it.

Michele Fiorentino is a //associate professor// in the DMMM at the Polytechnic University of Bari. Contact him at michele.fiorentino@poliba.it.

Michele Gattullo is a //researcher// in the DMMM at the Polytechnic University of Bari. Contact him at michele.gattullo@poliba.it.

Antonio Boccaccio is a //researcher// in the DMMM at the Polytechnic University of Bari. Contact him at antonio.boccaccio@poliba.it.

Vitoantonio Bevilacqua is a //researcher// in the //Department of Electrical and Computer engineering (DEI)// at the Polytechnic University of Bari. Contact him at vitoantonio.bevilacqua@poliba.it.

Giuseppe L. Cascella is a //researcher// in the DEI at the Polytechnic University of Bari. Contact him at giuseppeleonardo.cascella@poliba.it.

Michele Dassisti is an associate professor in the DMMM at the Polytechnic University of Bari. Contact him at michele.dassisti@poliba.it.

Antonio E. Uva is a //associate professor// in the DMMM at the Polytechnic University of Bari. Contact him at antonio.uva@poliba.it.