

ISTI NEWS

Refocusing Research at ISTI in the fight against Covid-19

The COVID-19 pandemic, caused by the new SARS-CoV-2 virus, has profoundly impacted our lives, creating severe health, social, and economic disruption worldwide. The emergency caused by the virus has challenged governments, health institutions and public authorities in an unprecedented manner, leading to a de-

mand for appropriate measures to contain the pandemic. The global scientific community has mobilised in response to this demand, and ISTI-CNR has followed the same path.

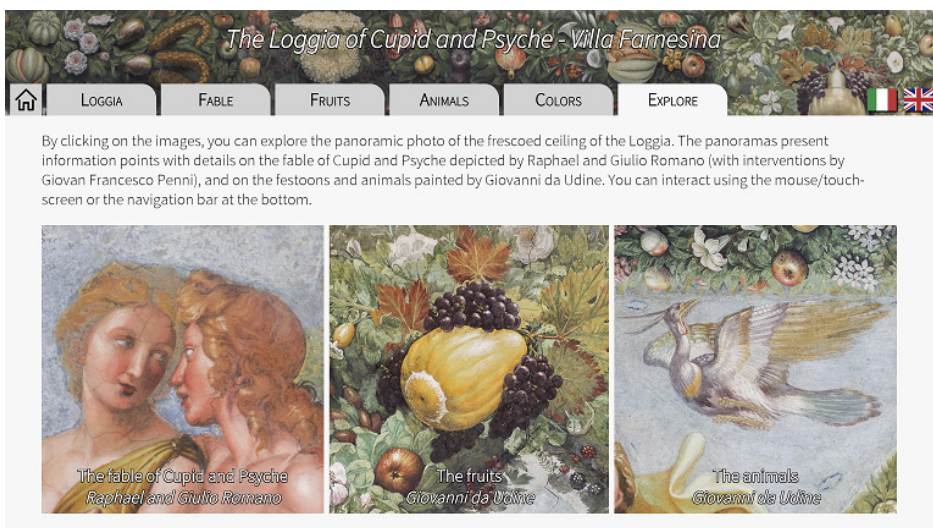
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A Digital Loggia for Raphael

At <http://vcg.isti.cnr.it/farnesina/loggia/>, you can observe at close distance both the beautiful stories of Cupid and Psyche, and the very particular pergola and

animal species painted by Raphael and his assistants in Villa Farnesina, the Roman residence of Agostino Chigi, a wealthy banker and generous client of Raphael.

[see page 29]



Editorial



Smart working at ISTI in the Covid-19 era

Research has always been a profession characterized by a high level of freedom. Researchers are free to select the topics of their activity (obviously under certain constraints) and the people with whom they collaborate. Consequently, researchers have always been eager to be equally free to decide on their working conditions, and particularly the time and the place. This latter has always been an issue with our central administration and a source of discussion.

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Smart working at ISTI in the Covid-19 era

For a number of reasons, CNR has never accepted that much research activity could be done anywhere and at any time, rather than being limited to in-office conditions, despite the fact that the establishment of welfare policies related to smart working were among the stated objectives of our General Director in 2019. One hard-to-solve issue concerns the different categories of staff at CNR. While researchers have some limited freedom (they can declare off-site work, but not from home), other categories of CNR employees are only allowed to work from their CNR offices.

When the Coronavirus epidemic led to the abrupt closing of all CNR offices (on March 6th), one of the few advantages was that this closure resulted in the exceptional introduction of the so-called Covid-19 smart working regime (in Italian *lavoro agile* – flexible working). The adoption of smart working meant that CNR staff could continue to work and study while remaining compliant with the governmental restrictions for lockdown caused by the coronavirus emergency. This has caused the most significant experiment on smart working ever conducted at CNR.

The aim of this brief editorial is to report some first impressions regarding this experience and to discuss the lessons learned and what it can teach us for the future. A caveat to our discussion is that what we have just experienced has not been real smart working, but rather a forced situation in which we had no choice about where (and how) we wanted to work. However, this experience has provided much food for thought: Can smart working be applied to complex research organizations such as CNR? What would the consequences be for the staff? And what are the main barriers to a successful continuation of this experience after the emergency has ended?

The first point to mention is that the past few months have certainly tested both our

organization and our resilience. Embarking on a well-planned smart working project would require months, if not years, to redesign organizational policies, technologies, and behaviour. Instead, at the beginning of March, the staff at CNR were mostly unprepared for the enormous upheaval implied by the national lockdown: we had to implement a new organization of work in just a few days. But Italians are fast to react to new situations, and this was the case with smart working. In agreement with the central administration, the directors of the CNR institutes established the minimum bureaucratic procedures necessary to record the details of who was working from home and on what. The staff was happy to endorse this new organization since an overwhelming majority was eager to continue to work and to contribute as much as possible to keeping Italy up and running while respecting the lockdown restrictions. In the case of ISTI, this included continuing to run existing research projects as well as starting several new activities, promptly designed in reaction to the Covid19 epidemic. The following Cover Story describes these new projects. Of course, there were some practical issues in moving our offices to our homes, both technical and organizational.

Portable computers were not the standard instrument for all staff; in particular, the administrative staff used desktop computers and paper archives (still). This issue

was solved either by taking desktop computers home or by buying new laptops, as well as by carrying a minimal set of paper documents home, when necessary. Neither was everybody used to discussing and interacting with colleagues using teleconference systems, but this gap was solved quickly.

In many cases, the speed of home internet-connections was insufficient to serve the smart working needs of an entire family, including children busy with distance learning programs set up by their schools. Here additional bandwidth provided by mobile phones helped a lot. Another issue was the need to cope with many administrative requirements incompatible with a smart working approach. As an example, let us consider the obligation to co-sign paper documents, often in duplicate copy with other colleagues. Reducing the number of bureaucratic procedures should be a must for CNR (and indeed for our entire nation), and this pressing need has been even more evident in the Covid-19 era.

Luckily, it was quite easy to solve the technical issues. The major problems were organizational. The size of family homes was often a problem, since in many families not everyone has the exclusive use of an entire room. Several members of staff had to work in kitchens or living rooms, with people passing through and many distractions.



The management of young children in lockdown was another major issue: many colleagues had to divide themselves between their professional roles and activities as tutor/technician/babysitter with one or more children requiring attention. An experience that either destroys or fortifies you forever is taking part in an international project meeting in teleconference while, at the same time, dealing with frequent interruptions from impatient kids.

The other side of the coin was that, since we all were in the same boat, we felt a sense of common fate, which created new bonds. We began to know each other's homes, as the backgrounds of virtual meetings showed kitchen furniture or toy shelves. We laughed when a colleague had to leave the virtual conference to let a yowling cat out of the room, and others laughed at us when we had embarrassing conversations with families while forgetting to mute our mikes.

Despite some issues and problems, after three months of smart working, the verdict is strongly positive. We have been able to run our research projects and to start new ones. We have succeeded in carrying out most of the administrative procedures at a distance, even the hiring of new employees or managing staff promotions. We found that virtual meetings do allow creative thinking and that working from home is sometimes much more productive than in the office. The latter can be especially true when we have to accomplish tasks that require a quiet context and an uninterrupted time slot, such as writing a new paper (assuming the home context is quieter than the office). We also found that virtual meetings save a lot of time and money (consider the time lost in travel and the hotel stays necessary to attend in-person meetings). Moreover, depending on the type of meeting, the level of efficiency does not change much if held in teleconference, e.g. intermediate project meetings.

Do we regret anything?

Admittedly, we have missed social contacts

and social life. But there is more to smart working than the reduction of social interaction. Staying alone at home and having only virtual connections with colleagues and friends is not the same as the real thing. In a complex research environment like ours, there are a number of implications on research management and organization. In the case of ISTI, organized in 12 quite large research groups, much informal discussion and exchange of information takes place during coffee or lunch breaks. We missed these chances for the free exchange of ideas, dissemination, and discussions, which often turned into productive brainstorming.

Our lab heads had to look for different ways to maintain relations with and among the lab members, as well as upholding the sense of belonging to the group – from formal teams on yet-another-platform to informal WhatsApp chats or virtual happy hours through video conferencing tools. Dealing with this sense of isolation will be very important if smart working becomes a part of our future, and mainly if applied to a just a fraction of the staff. It is essential that smart workers do not miss chances and opportunities because they are less visible to their colleagues.

Interaction with colleagues using email or chats outside office time was already common place before lockdown. It helped in planning the next day activities or to promptly manage urgent tasks. In this period, we have found that continuous working from home reduced the perception of distinction between work and non-work time, with an increased risk of remaining always connected to work activities and a decrease in the quality of personal time.

Finally, to judge fairly the results of what has happened during this big collective experiment, we will have to analyze our research production in the next months. And, among other things, this analysis will need to take into account gender issues.

Some early studies have highlighted how the number of preprints submitted by female

scientists has dropped since the beginning of lockdown¹. This is a signal that the need to balance home/family care with research has perhaps been more difficult for women than for men. An indictment on modern society, indicating that we still have a way to go before acquiring full gender equality? However, we must remember that what we have just experienced has been heavily influenced by external factors such as the closure of schools; this would not hold for smart working projects under normal conditions. In these three months, we have experienced a forced, anomalous form of smart working, without the possibility of alternating work at home with activity in the Institute. However, the experience overall has been positive, and we view smart working as an opportunity rather than a penalizing factor.

To conclude, the mainly positive results of this smart working experience encourage us to petition our central administration and direction to seriously consider keeping open a flexible smart working option for the post-Covid-19 period. This should be studied as the possibility to alternate between on-site presence and smart working, with modalities and objectives defined among colleagues, locally rather than centrally.

Last but not least, the smart working period has had one negative side effect. The former Director of ISTI, Claudio Montani, officially retired at the beginning of June but, clearly, we were unable to celebrate this moment. An official goodbye party for Claudio is one of the first events scheduled for the post-Covid19 period, and will be another good reason for celebrating our physical return to the Institute.

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[1] P. Vincent-Lamarre, C. R. Sugimoto, V. Larivière, "The decline of women's research production during the coronavirus pandemic", *Nature Index*, May 19th, 2020, <https://www.natureindex.com/news-blog/decline-women-scientist-research-publishing-production-coronavirus-pandemic>

Refocusing Research at ISTI in the fight against Covid-19

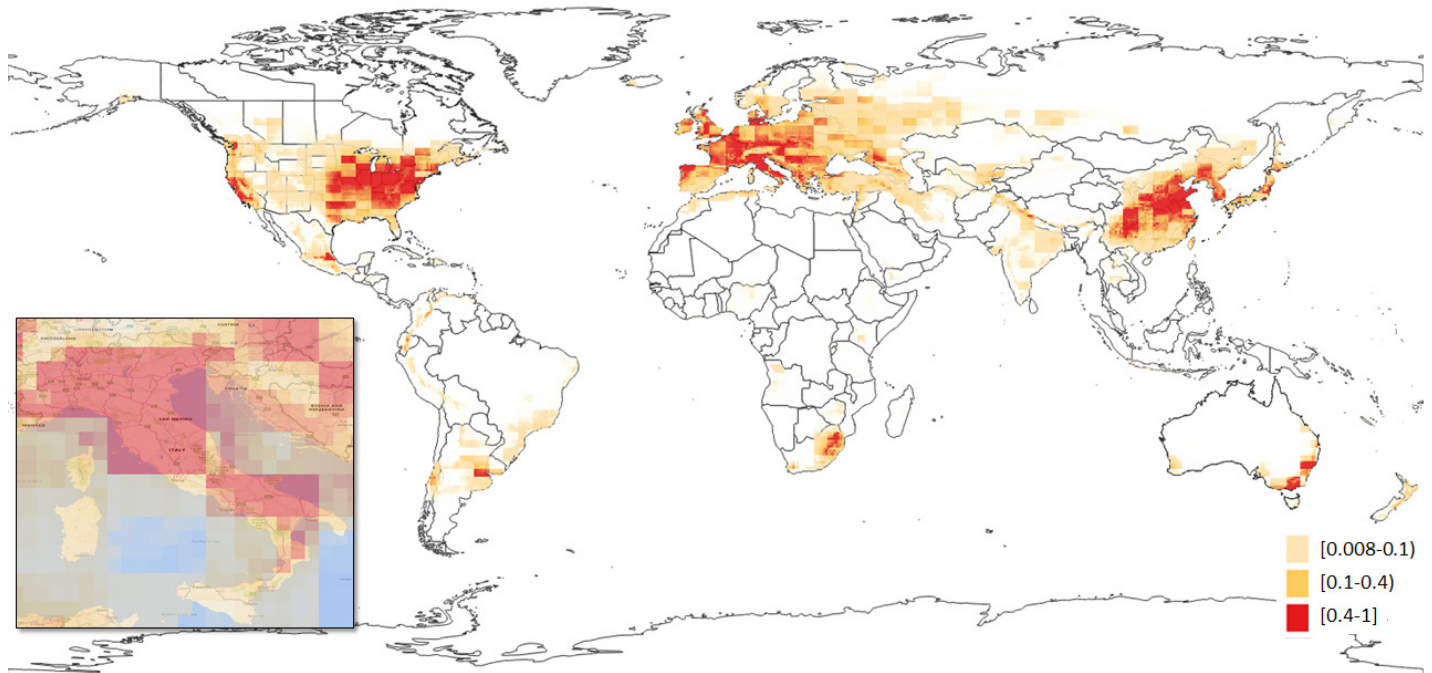
As an institution dedicated to front-line, reality-driven research, we are now playing an active role, nationally and internationally, proposing scientific solutions and technologies that are effective in the fight against COVID-19.

determining factors of the pandemic and to verify the efficacy of containment measures.

Since the early days of the outbreak of the disease, a team from the [Infra Science group](#)¹ part of the Networked Multimedia

sphere Monitoring Service), and elevation (data from NOAA ETOPO2).

The same model, accessible on the [D4Science infrastructure](#), is now being studied with respect to an extension aimed at



Global-scale probability distribution of SARS-CoV-2 high infection rate

Over the last few months, ISTI labs and research groups have been working on designing and delivering ICT solutions covering almost the entire continuum of responses to the COVID-19 epidemic. Proposals include epidemiologic analyses, disease diagnosis and prognosis, outbreak containment and mitigation, social and environmental impact assessment, i.e. cross-sectional support to science and research. Here below, we provide a brief overview of the diverse COVID-19 inspired research activities at our institute.

Assessment of the virus outbreak: the epidemiologic perspective.

Epidemiological evidence is essential to understand the occurrence, distribution, and

Information Systems Laboratory ([NeMIS-Lab](#)), has developed and published a [Suitability Map of COVID-19 Virus Spread](#). Based on a Maximum Entropy model, this map postulates *likely* locations for COVID-19 diffusion, i.e. places that might favour a spread of the virus in terms of environmental parameters. Interestingly, the model indicates the Hubei region in China and Western USA as high-probability locations for diffusion of the virus, even though data from these regions was not used to train the model. The parameters used by the model include the average annual surface air temperature in 2018, the average yearly precipitation in 2018 (both based on NASA data), CO2 emission (natural and artificial) averaged between January 1979 and December 2013 (data from Copernicus Atmo-

the high-resolution identification of those areas in the world most susceptible to the growth of infections, plus the delivery of a pre-screening methodology for COVID-19 patients in order to identify those subjects most at risk of aggravation. This research is funded by the European Open Science Cloud (EOSC) COVID-19 - Fast Track Funding, after evaluation by a specific EOSC scientific committee.

The [Text Analysis group](#)² of NeMIS is working on a class of Machine Learning technologies, named “supervised prevalence estimation” or “quantification”, which is particularly applicable to epidemiological analyses. While traditional classification is

[1] For more info, please contact [Gianpaolo Coro](#).

concerned with learning to assign an individual subject (for instance, a patient) to a class (such as COVID-19), quantification deals with learning to estimate the percentages of individuals that belong to a specific class. Using this technique, it is possible to estimate how many subjects in a given sample belong to the COVID-19 class with better accuracy than traditional classification techniques based on learning. This work could help epidemiologists to obtain more precise estimates wrt virus occurrence.

COVID-19 and its clinical management: diagnostic and prognostic stratification

In addition to its rapid spread³ and high reproduction factor⁴, COVID-19 has severely challenged health and care systems due to the wide spectrum of clinical presentations and outcomes⁵. The rapidity of respiratory deterioration in the most badly affected patients, including some of the younger ones, has been striking and often unforeseeable. The novelty of the disease and the lack of guidelines for COVID-19 management have increased the heterogeneity of the, mainly empirical, approaches to prevention, diagnosis and treatment.

Clinicians are currently struggling to understand the main risk and prognostic factors that are instrumental in detecting patients in need of immediate specialty care and in defining the clinical needs of different groups of patients. The [Signals & Images Lab](#)⁶ has begun a research activity in collaboration with two radio-diagnostic units and the pneumology division of the university hospital in Pisa. The aim is to define strategies and methods, based on Artificial Intelligence and Machine Learning, to identify prognostic and predictive factors of COVID-19 outcomes. The starting points are clinical and imaging data from the Pisan area, including radiomic analyses of pulmonary computer tomography scans. The bilateral interstitial pneumonia typically caused by SARS-CoV-2 shows a characteristic pattern of asymmetric and “patchy” lesions, mainly involving the pulmonary periphery, whose qualitative and quantitative evaluation seems to correlate with disease progression and mortality. A

research activity, in collaboration with three hospitals (in Reggio Emilia, Milan, and Messina) and the National Institute of Public Health, follows the same approach.

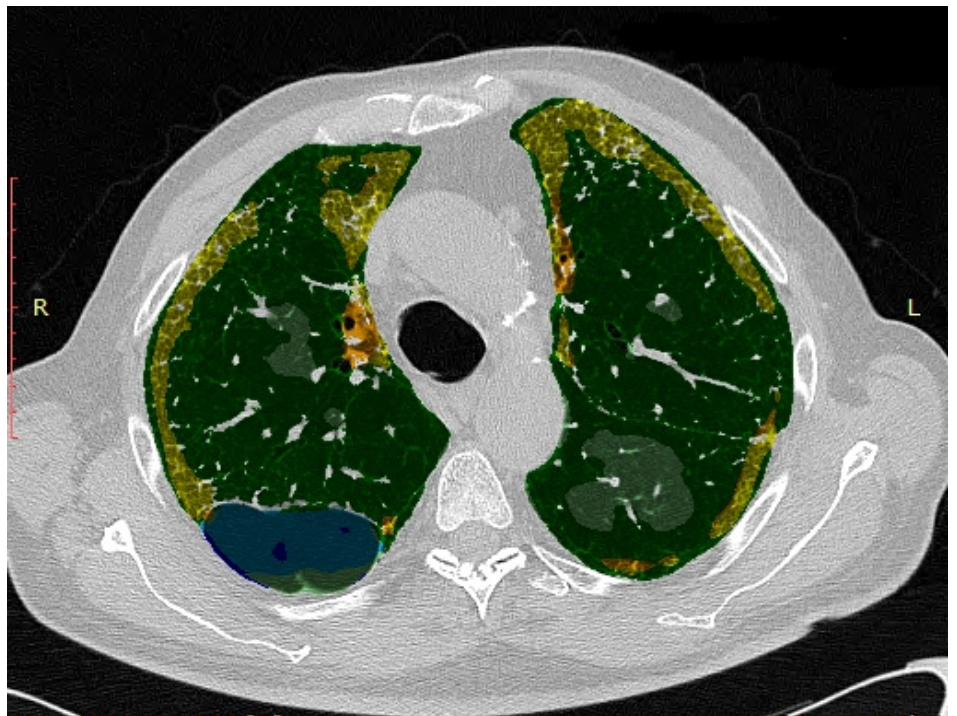
Life during lockdown: technologies for screening and special care

The difficulties recorded in the clinical management of COVID-19 have evidenced the need for novel methods to interact with the population and to monitor individuals outside the traditional hospital environment. Teleconsultation and remote monitoring technologies appear powerful applications to gather pandemic data and real-time clinical feedback as well as to provide care and support to quarantined patients or categories with special needs (such as the elderly or people suffering from chronic diseases).

The [Signals & Images Lab](#)⁷ is implementing a system for teleconsultation and teleassistance, in close collaboration with the NW Tuscan Health Authority (Azienda USL

Toscana nord ovest), and the Department of Emergency Medicine of the Cisanello Hospital, Pisa. The system will be offered to SARS-Cov2 patients, chronic patients, and citizens at large. Another teleconsultation system will be provided to the Emergency Health Service of the central Tuscan Health Authority, in order to provide a second evaluation of signs, symptoms and ultrasound images. Starting from the results of a former EC project [e-Rés@mont](#), these activities are conducted in collaboration with the CNR Institute of Clinical Physiology. Both systems feature Artificial Intelligence based methods to provide classifications of pathologies, and clinical decision support theory to provide suggestions based on clinical protocols and on physicians' knowledge.

To support and care for the elderly population, the [Human Interface in Information System Lab](#)⁸ is developing a platform that exploits connected smart objects and home-deployed sensors, in order to monitor health status and activity remotely.



Lesions (coloured) caused by the pulmonary interstitial pneumonia as detectable in a computer tomography scan

[2] For more info, please contact Fabrizio Sebastiani.

[3] Yuan et al. Monitoring Transmissibility and Mortality of COVID-19. In Europe. *Int J. Infect Dis.* 2020.

[4] Liu et al. The reproductive number of COVID-19 is higher compared to SARS coronavirus. *J. Travel Med.* 2020.

[5] Huang C. et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan. *Lancet* 2020 395: 497-506.

[6] For more info, please contact Sara Colantonio.

[7] For more info, please contact Massimo Martinelli.

The platform enables intuitively specifiable, customizable rules, which define how to exploit connected objects (e.g. lights, pill dispensers), sensors (e.g., temperature, oximeter, and motion), devices and applications through relevant automation. The remotely collected data is viewable, and can be useful for caregivers or relatives in order to monitor the users' status and behaviour (e.g. movements in the home, outings, monitoring medication intakes, or physiological parameters). The automation provided by this platform can help people in their daily activities, provide reminders, and report alarm situations using various types of communication channels (e.g., Alexa speakers, tablet notifications, mail, SMS). This platform can be applied to monitor and support all those in isolation due to COVID-19 and is currently being installed in eight elderly adults' houses in three European countries in the context of the AAL PETAL project

The lockdown measures adopted to contain the pandemic have imposed a set of limitations, including restrictions on shopping. This has raised numerous difficulties for people with disabilities and elderly subjects who may need support. Online shopping can lead to further problems: web sites and applications can be inaccessible or difficult to use, people might not be able to interact with the web applications and the requested technologies, and so on. Moreover, even when receiving products at home, handling food items (e.g., packs, boxes, etc.) can be a challenging task for people with special needs, such as the elderly or visually impaired. To overcome these issues, a team from the Signals & Images Lab⁹ has developed SelfLens, a portable tool designed to support people to quickly read labels or obtain additional information, when shopping at home or in the shop. SelfLens features several facilities and services, such as product recognition, product information (e.g., ingredients), and product purchasing with a simple touch. It is a portable assistive technology that can be used regardless of personal abilities and skills, and requires neither a smartphone nor a sophisticated device.



SelfLens in action

SelfLens is a low-cost solution that can contribute to ensuring the independence of people in periods of emergency such as that caused by COVID-19.

Measures for pandemic containment and their enactment

Social distancing is one of the most effective measures put in place to contain the outbreak of the virus.

Though beneficial, compliance with this measure is challenging as it profoundly affects daily life, and imposes an urgent re-thinking of standard ways of shopping, moving, working, and vacationing.

The AMIR group¹⁰ of the NeMIS-Lab is studying solutions based on Deep Learning and Computer Vision to automatically detect the correct usage of face masks and compliance with distancing guidelines from surveillance cameras. The technique for mask usage detection is based on a deep neural network bootstrapped using large synthetic datasets, automatically generated in virtual worlds, and fine-tuned on smaller, manually labelled real datasets, including face masks. Social distancing is assessed using a deep learning-based person-detection technique and an easy-to-calibrate perspective-aware solution that makes it possible to estimate the distance between people according to their position in the captured image.

Another team from the Software Engineering and Dependable Computing Lab and the Wireless Network Lab¹¹ is working



The distance-detection tool in action

[8] For more info, please contact Fabio Patenò.
 [9] For more info, please contact Barbara Leporini.
 [10] For more info, please contact Giuseppe Amato.
 [11] For more info, please contact Eda Marchetti or Paolo Barsocchi.

on an application for automatically guaranteeing indoor social distancing, thanks to the adoption of a privacy-preserving Indoor Localization System (ILS). The approach enforces privacy compliance, by making the environment automatically able to self-organize and respond to distancing needs with respect to General Data Protection Regulation (GDPR) provisions. The objective is to prevent distance reduction in crowds without violating the data owner's privacy requirements.

The application is suitable for indoor systems where users are moving inside a building through a sequence of waypoints and lets them follow self-configured indoor paths to safely access services/places of interest. Specifically, the approach automatically takes actions to limit or prevent users' social contacts, and via fly computing suggests pedestrian paths that minimize closeness to other users. From a technical point of view, the privacy-preserving Indoor Localization System is able to preserve the privacy of the data collected by means of the integration of a GDPR compliant Access Control system. This system can be applied to various application scenarios, including museums, airports, and supermarkets.

The social and environmental impact of COVID-19

The COVID-19 pandemic has had far-reaching consequences, going well beyond the spread of the disease itself to touch the political, social, economic, and environmental spheres.

A team from the Knowledge Discovery and Data Mining Lab¹², in cooperation with the telecom company Wind Tre, Italian National Institute of Health (Istituto Superiore di Sanità - ISS) and other national and international institutions, has studied collective mobility patterns to plan the restart of production and economic activities, put on stand-by to fight the diffusion of the epidemic. They used mobile phone data to infer the movement of people between Italian provinces and regions, to analyse the incoming, out-coming and internal mobility flows

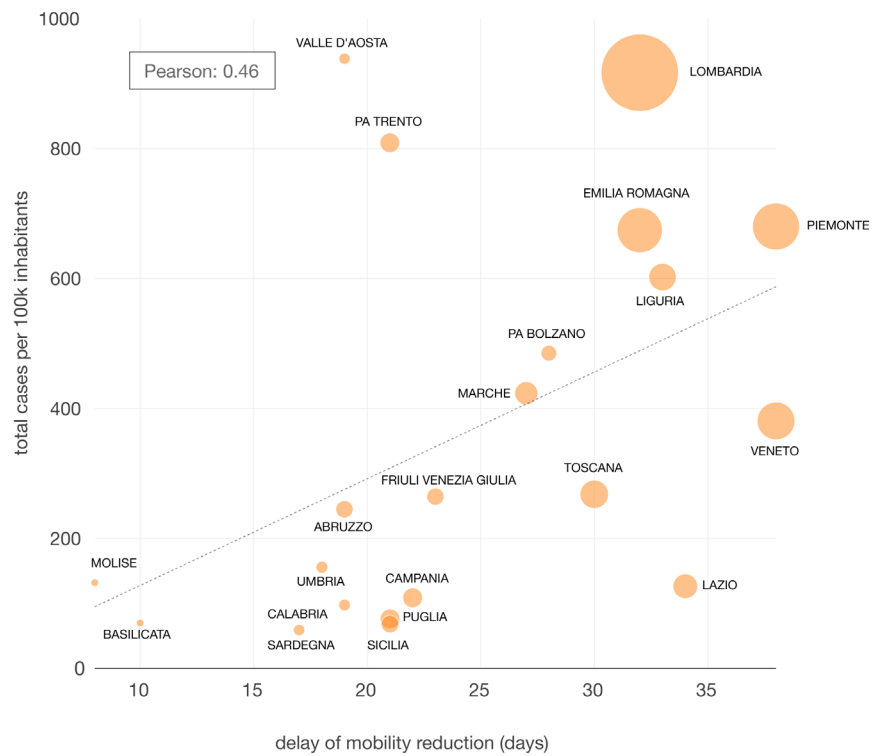
before and during the national lockdown, after the closure of non-essential productive and economic activities as well as after the application of partial lockdown release. The population flow across provinces and regions has enabled the modelling of the relationship between human mobility and viral transmissibility in each province or region. This relationship is a tool to drive countermeasures on the occurrence of a sudden reactivation of the epidemic. Mobile phone data, even when aggregated to preserve individual privacy, is a useful data source to track the evolution in time of human mobility, hence making it possible to monitor the effective

ness of control measures such as physical distancing.

The stop of unnecessary production activities during lockdown has also caused a drastic reduction in anthropic impact on the environment, including coastal and marine ecosystems, especially in the vast areas of urban agglomerations.

The InfraScience group¹³ of the NeMIS-Lab is taking part in the CNR inter-departmental project SNAPSHOT, which will study and report on this impact. SNAPSHOT – which stands for Synoptic Assessment of Human Pressures on key Mediterranean Hot Spots – is a key action of the BlueMed network

Relation between lockdown delay and number of confirmed infections



Delay in mobility reduction vs total number of cases per 100k inhabitants. In the scatter plot, the horizontal axis has the number of days between the first time $R_t > 1$ and the beginning of the national lockdown. The vertical axis has the cumulative incidence of confirmed SARS-CoV-2 infections per 100k inhabitants (as of May 15th, 2020). The size of the circles is proportional to the total number of positive cases in the period (Pearson coefficient= 0.46, $p < 0.05$, $r^2 = 0.21$). R_t is the net reproduction number, which represents the mean number of secondary infections generated by one primary infector, in the presence of control interventions and human behavioural adaptations.

[12] For more info, please contact Luca Pappalardo.
 [13] For more info, please contact Gianpaolo Coro.

(involving CNR, Stazione Zoologica Anton Dohrn, National Institute of Oceanography and Applied Geophysics, and ENEA).

The project will verify the evolution of the anthropic impact on the Mediterranean Sea, in areas with a high urban and industrial density, due to national lockdowns.

Through Open Data and Open Science approaches, the project will quantify and publish the status of marine ecosystems, and will integrate in situ measurements with additional observations in coastal hot spots and qualitative indications from citizens.

Science aiding science to fight COVID-19

Leveraging its well-established role in the Open Access and Open Science community, ISTI-CNR is promoting several initiatives to support the scientific and clinical communities in their fight against the pandemic and to inform citizens and society at large.

Responding to an explicit request from the European Commission, the [OpenAIRE](#) infrastructure, whose technical coordination is led by the [InfraScience group](#)¹⁴ of the [NeMIS-Lab](#), released the [COVID-19 Scientific Gateway](#), an advanced portal for the collection and dissemination of scientific results related to the COVID-19 and Sars-CoV-2 virus.

The Gateway provides access to publications, research data, research software, and projects that may be relevant to combat COVID-19.

The Gateway rests on top of the [OpenAIRE Research Graph](#). It is one of the largest, open, knowledge graphs about research material, aggregating records about research results, funders, authors, organizations, and projects from 12,000+ data sources.

The portal exploits the multitude of web sources on COVID-19 and combines text mining and inference techniques to identify the portion of the Graph related to COVID-19.

It offers users facilities to: (i) publish research results in [Zenodo.org](#), (ii) tag results of searches as COVID-19 related, (iii) include domain experts in the loop to validate the results.

[OpenAIRE](#), in synergy with [ELIXIR](#) and [Research Data Alliance](#), has operated in the broader context of the [EOSC](#) to define and recommend guidelines that scientific publishers, data repositories, and institutional repositories should follow to facilitate the identification of COVID-19 related research outcome.

ISTI-CNR is now organising a series of events to raise awareness among Italian researchers and clinicians about the importance of Open Science and research data sharing in the context of COVID-19 outbreak.

A first seminar (webinar) will introduce the topic, followed by a series of tutorials to explain how to manage, prepare and share research data related to COVID19. The tutorials will focus on different types of data (clinical, omical, epidemiological, etc.) and will present tools to share data and make them accessible to other researchers and clinicians all over the world.

The webinar series is part of a broader collaboration, strongly supported by the European Commission, between the Italian nodes of [OpenAIRE National Open Access Desk](#), [ELIXIR](#), and [Research Data Alliance](#)¹⁵.

The events will be highly interactive, thanks partly to the use of tools such as [mentimeter](#). It will take place in July (introductory webinar), and September (series of tutorials). It will be open to all clinicians, researchers and policy makers in Italy. Information about the series of events is disseminated on several sites ([CNR event page](#), [OpenAIRE webinar page](#), [ELIXIR platform](#), [ISTI website](#)).

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 [15] For more info, please contact Emma Lazzeri.

ACCORDION

Adaptive edge/cloud compute and network continuum over a heterogeneous sparse edge infrastructure to support NextGen applications Funded by Horizon 2020

There is increasing evidence that the edge computing concept is going to play a dominant role in forthcoming technological developments, disrupting economies on a large scale. World-level cloud providers rushed to obtain the lion's share of this market, but edge computing is intrinsically more "democratic" than cloud computing. In fact, its distributed and localized nature can be an antibody for big trusts' dominance. By synergistically employing edge computing with upcoming technologies such as 5G, the EU could capitalize on its local resources and its SME-dominated application development landscape to achieve an edge-computing-driven disruption with a local business scope. With this objective, the ACCORDION project is establishing an opportunistic approach aimed at bringing together edge resources/infrastructures (public clouds, on-premise infrastructures, telco resources, and even end-devices), that can support NextGen interactive and latency-aware application requirements. ACCORDION will

intelligently orchestrate the compute & network continuum between edge and public clouds, using the latter as a capacitor. Deployment decisions will also take into consideration privacy, security, cost, time and resource type criteria.

The adoption rate of novel technological concepts by SMEs in the EU will be boosted through an application framework, leveraging DevOps and SecOps practices to facilitate transition to the ACCORDION system. ACCORDION places great emphasis on European edge computing efforts (MEC, OSM) and three highly anticipated NextGen applications on collaborative VR and multiplayer mobile-gaming, contributed by the involved partners. It is expected that ACCORDION will radically impact the application development and deployment landscape, also directing part of the related revenue from non-EU vendors to EU-local infrastructure and application providers. ISTI-CNR, and the HPC Laboratory in particular, is strongly



involved in the ACCORDION project with some of its researchers playing a distinct role in the project management bodies: Patrizio Dazzi (project coordinator), Emanuele Carlini (technical manager) and Massimo Coppola (scientific manager). CNR also provides the financial management (ISTI PeC office) and the communication manager (Beatrice Rapisarda, IIT-CNR).

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<http://www.accordion-project.eu>



TEACHING

A computing toolkit for building efficient autonomous applications leveraging humanistic intelligence

Funded by Horizon 2020

Industry and society are experiencing the transformational impact of the autonomous systems revolution, empowered by automation capabilities offered by Artificial Intelligence (AI). Cyber-Physical Systems of Systems (CPSoS) define a multi-faceted and dynamic environment, where autonomy is fundamental to govern the complexity of interactions between the virtual and physical worlds with minimal human intervention. However, even when the most advanced degree of autonomy is exercised, the human is a variable that cannot be ruled out of the CPSoS equation, particularly in safety critical scenarios like autonomous transportation. TEACHING puts forward a vision of humans at the centre of autonomous CPSoS by embracing the concept of Humanistic Intelligence, where the cybernetic and biological entities cooperate in a mutual empowerment towards a shared goal and where human feedback becomes a crucial driver for CPSoS adaptivity.



TEACHING addresses the challenge by integrating AI with fundamental concepts of security and dependability stemming from the AI-human-CPSoS interactions, as well as by considering their impact on the underlying computing system. TEACHING develops a human-aware CPSoS for autonomous safety-critical applications, based on distributed, energy-efficient and dependable AI, leveraging edge computing platforms, and integrating specialized computing fabric for AI and in-silico support for intelligent cybersecurity. TEACHING will design computing software and systems supporting the development and deployment of adaptive and dependable CPSoS applications, making it possible to ex-

plot a sustainable human feedback to drive, optimize and personalize the provisioning of the services offered. Project outcomes will fundamentally impact the development of autonomous safety-critical systems, providing means to improve their safety, dependability and overall acceptance. This impact will be demonstrated by the two TEACHING pilots concerning autonomous driving and aviation. The project is coordinated by Davide Bacciu from the University of Pisa. ISTI-CNR is involved in the TEACHING project with two of its laboratories: HPC Lab and WN Lab. Our institute is also leading Work Package 2 and is responsible for innovation coordination. The key persons involved are: Patrizio Dazzi, Emanuele Carlini, Massimo Coppola (HPC Lab), Alberto Gotta, Pietro Cassarà and Manlio Bacco (WN Lab).

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IMAGO

Co-funded by the Italian Ministry of Education, University and Research (MIUR) under the Research Projects of National Interest (Progetti di Ricerca di Interesse Nazionale – PRIN) program

IMAGO (Index Medii Aevi Geographiae Operum) aims at creating a knowledge base of the critical editions of medieval and humanistic geographical works in Latin (VI-XV centuries). Up to now, this knowledge has been collected in many paper books and a number of databases, making it difficult for scholars to retrieve it easily and to acquire a complete overview.

The goal of the project is to develop new tools that satisfy the needs of the research community, especially those scholars interested in Medieval and Renaissance humanistic geography, i.e. Latin texts which



describe the knowledge and representation of the world of that period. The idea of the world created by Medieval and Renaissance culture over ten centuries is crucial to our understanding of the level of geographical knowledge and the development of Western thought in European history.

Using Semantic Web technologies, ISTI will develop an ontology providing the terms to represent this knowledge in a machine-

readable form. A semi-automatic tool will help scholars populate the ontology with data extracted from authoritative critical editions. The tool will automatically save the resulting graph into a triple store. ISTI will develop a Web application on top of this graph that will allow users to extract and display the information stored in the knowledge base in the form of maps, charts, and tables.

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4SECURAIL

Formal Methods and CSIRT for the Railway Sector
Funded by Horizon 2020

In December 2019, the Formal Methods and Tools (FMT) laboratory of ISTI began a participation in 4SECURail [L1,L2] - a project funded by the European Union Horizon 2020 Shift2Rail Joint Undertaking.

This project has two main objectives: the setup of a Formal Methods Demonstrator for the evaluation, in terms of costs, benefits and required learning curve, of the impact of the use of Formal Methods for the rigorous specification of the components of a railway signalling infrastructure, and to design a Computer Security Incident Response Team (CSIRT) for joint EU-Rail cyber security.

While it is recognized that the adoption of a rigorous specification methodology based on formal methods would definitely improve the dependability of railway signalling systems, a detailed analysis of the potential

advantages is still missing.

Researchers from the FMT group will shed more light on this issue with the design of a Demonstrator to evaluate the possible impact of the use of Formal Methods within a system specification process that could be adopted by railway infrastructure managers. The ISTI-CNR demonstrator design efforts will be complemented in the project by SIRTi SpA for the selection and specification of a signalling subsystem to be used as case study, and by FIT Consulting Srl for a costs/benefits analysis.

A second team in the project, led by Hit Rail B.V. with the collaboration of UIC (International Union of Railways) and Tree Technology, will deliver a collaboration platform for a European Railway Computer Security Incident Response Team (CSIRT), designed to



coordinate the Cyber Security response actions of the separate railway security teams.

The 4SECURail project is expected to end on November 30th 2021 and is coordinated by the engineering consulting firm Ardanuy Ingeniería, S.A.

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EV-CHIP

Funded by the ERANET SGplusRegSys Program

The wide-scale electrification of private transport will have a profound impact on the operation of the power grid, representing a challenge both for distribution system operators and large commercial energy users such as universities, hospitals, business parks and shopping centres.

In this context, the research objective of EVCHIP is to explore and validate a business model to establish the commercial value of the aggregation of EV charging services in a campus-like facility.

EV-CHIP stands for Electric Vehicles Charging Platform for Community Demand Response Aggregators and is an ERA-NET project co-financed by the Italian Ministry of Research (MUR) and the Sustainable Energy Authority of Ireland (SEAI). The consortium has two partners: ISTI and University College Dublin, Ireland. The project is coordi-

nated by Fabiano Pallonetto from University College Dublin, Ireland while Chiara Renso from the HPC Lab is the ISTI-CNR coordinator.

The project research goals are the assessment of a standard methodology to evaluate the impact of electric vehicle charging points at the distribution level and the validation of a real-time predictive algorithm for the bi-directional power management of the charging stations. EV-CHIP will explore the potential for an aggregated electric vehicle (EV) charging optimisation in a campus/shared facility, leveraging a rich set of data resources for building energy consumption, vehicle operation and parking and wholesale electricity pricing.

ISTI will provide and analyze the CNR Pisa Research Campus parking occupancy patterns data from the "Smart Area" project.



EVCHIP

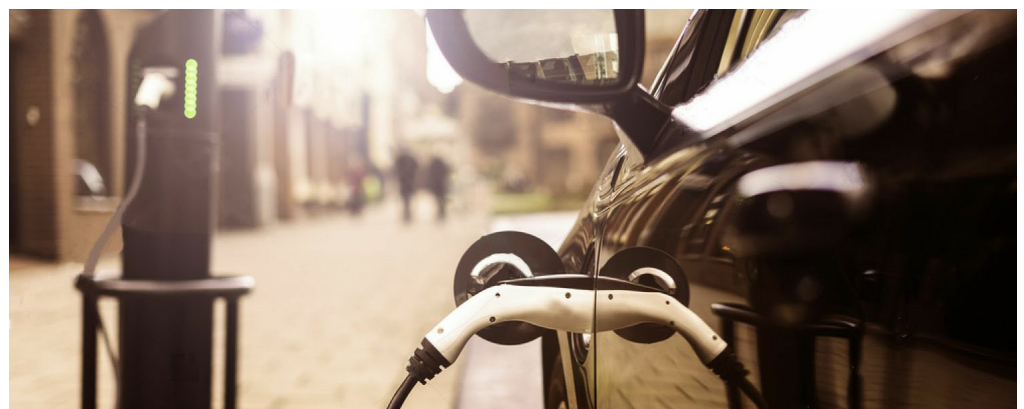
Researchers will apply a suite of modelling approaches to predict how centrally-optimised EV charging could provide suitable charging volumes at competitive rates for drivers while balancing facility-level electricity requirements and minimising grid usage.

The benefits of the EVCHIP project are multi-fold, and include social, environmental, and economic impacts. Evaluating EVCHIP's social impact in particular will yield two primary benefits: social engagement through execution of the project itself, and validation of the underlying business model.

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TIGHT

Co-funded by the Italian Ministry of Education, University and Research (MIUR) under the Research Projects of National Interest (Progetti di Ricerca di Interesse Nazionale – PRIN) program

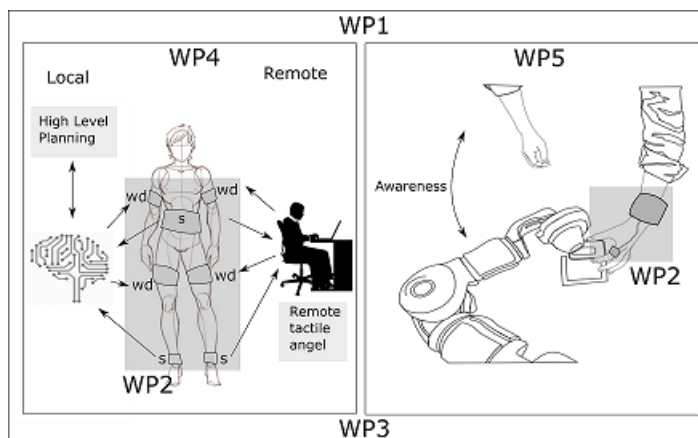
In a world where humans work with machines and communicate via computers or smartphones, we need to re-consider the concepts of confidence and awareness towards artificial devices. Confidence is essential, since it allows humans to tackle both known and unfamiliar tasks with hope, optimism, and resilience. Awareness enables confidence, because the more we know about the task we have to perform, and about the agent we must interact with, the more we are confident. In the TIGHT (Tactile InteGration between Humans and arTificial systems) project, the aim is to communicate that sense of awareness to humans that

need to be assisted by other humans or by artificial systems. The mutual understanding between a human and her/his collaborator, no matter whether another connected human or a robot, will be enabled by novel tactile communication paradigms formulated within TIGHT. The tactile channel has several advantages, but it is still under-exploited in complex assistive and industrial applications. Capitalizing on the successful results of the newly established field of wearable haptics, TIGHT will tackle the technological and neuroscientific challenges that derive from the development of wearable haptic interfaces suitable for human-human (e.g.,

visually-impaired people guidance) and human-robot (e.g., cooperative assembly) collaboration scenarios.

The partners involved in the TIGHT project are: 'Università di Siena (coordinator), 'Università di Pisa', 'Università degli Studi di ROMA "Tor Vergata"', 'ISTI-CNR', and 'Politecnico di Milano'. The contribution of ISTI-CNR will focus on the design of user interfaces thanks to its knowledge and experience in the Human-Computer Interaction and accessibility field.

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Role of WP2 within the project and interactions with the others WPs. WP2 will deal with the design and low-level control of tactile (WD) and sensing (S) systems, targeting the two use-cases of TIGHT, i.e. VIP assistance (WP4) and human-robot collaboration (WP5, e.g. human-robots in industrial settings). System design will be carried out in close collaboration with WP3, and it will be informed through all the phases by continuous feedback provided by neuroscientific investigation on human somato-sensory apparatus (WP1) and end users' needs and requirements (WP4, WP5). WP4 and WP5 will also offer real-world test beds of the proposed technology.

SOUL

Urban seismology in the historic center of Lucca (Sismologia Urbana nel Centro Storico di Lucca)

Co-funded by **Fondazione Cassa di Risparmio di Lucca**



The study of the dynamic effects induced on buildings by the surrounding urban environment is a cutting-edge research topic in the field of heritage preservation. This study involves skills from engineering, geology and physics and is sometimes referred to as “urban seismology”. Since 2015, ISTI-CNR has been conducting experiments in the historic center of Lucca, aimed at measuring and analyzing the dynamic behavior of age-old masonry towers. In particular, the ambient vibrations of the San Frediano bell tower and

the “Clock” Tower have been continuously monitored in recent years: high-sensitive vibration monitoring systems were installed on the structures, with the aim of recording their response to the dynamic actions of the surrounding environment (wind, traffic, crowd movements, earthquakes, etc.).

These experiments are among the few reported so far in the scientific literature and have proved to be a valuable source of information on the structural properties of the towers, and their structural health. The SOUL project will continue, complete and enhance these studies in the center of Lucca. It will provide the technical and scientific community, and the citizens of Lucca with a study on the sources of vibrations within the historic center and an in-depth dynamic characterization of some iconic monuments.

The project is carried out by the Laboratory of Mechanics of Materials and Structures of ISTI-CNR in partnership with the Italian National Institute of Geophysics and Volcanology (INGV), and with the collaboration of the Municipality of Lucca.

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WeAreClouds@Lucca

WAC@Lucca - WeAreClouds@Lucca

Co-funded by **Fondazione Cassa di Risparmio di Lucca**

To date, most cities of historic and cultural interest already have a network of cameras on their territory, typically located in the access areas or the main areas of interest and usually used by law enforcement or for simple environmental monitoring. The Municipality of Lucca already has over 150, which will become even more thanks to the investments in progress.

With the WAC@Lucca research project, we will develop an information system based on the network of pre-existing cameras, capable of monitoring the main public places and access points to evaluate the presence of people in real-time and statistically over time and, without affecting individual privacy, also provide information on the age

and gender of individuals. The system will analyze the video flow from each camera in real-time and the audio coming from the microphones within a centralized system, where the data will be securely stored as required by the law.

By developing an intelligent system capable of analyzing the flow of people in real-time, it will be possible to acquire a complete view of the city from multiple points of view, ranging from tourism to security. Audio recording will also go hand in hand with video recording. Having an environmental audio monitoring of specific areas of interest would reduce the false positives deriving from image analysis. It would also provide, continuously and automatically, useful information on

noise pollution during events, demonstrations, or normal life within the city.

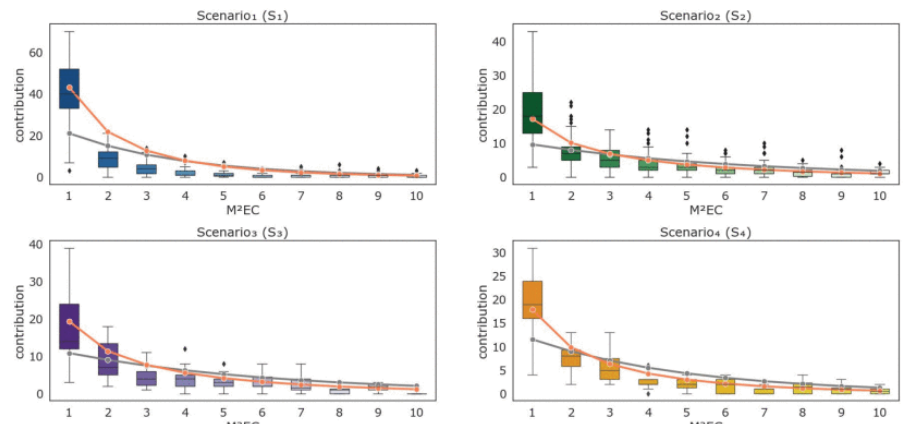
There are two ISTI research groups involved in this project: Artificial Intelligence for Multimedia Information Retrieval represented in this project by Fabrizio Falchi, and the Signals and Images Laboratory represented by Andrea Carboni. The project is the result of a collaboration between ISTI and Municipality of Lucca.

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A probabilistic model for the deployment of human-enabled edge computing in massive sensing scenarios

D. Belli, S. Chessa, L. Foschini, M. Girolami
IEEE Internet of Things Journal, vol. 7. IEEE, 2020.

Human-enabled Edge Computing (HEC) is a recent smart city technology designed to combine the advantages of massive Mobile CrowdSensing (MCS) techniques with the potential of Multi-access Edge Computing (MEC). In this context, the architectural hierarchy of the network shifts the management of sensing information close to terminal nodes through the use of intermediate entities (edges) bridging the direct Cloud-Device communication channel. Recent proposals suggest the implementation of those edges, not only employing fixed MEC nodes, but also opportunistically using as edge nodes mobile devices selected among the terminal ones. However, inappropriate selection techniques may lead to an overestimation or an underestimation of the number of nodes to be used in such a layer. In



Comparison of models with the four scenarios.

this work, we propose a probabilistic model for the estimation of the number of mobile nodes to be selected as substitutes of fixed ones. The effectiveness of our model is veri-

fied with tests performed on real-world mobility traces.

DOI: 10.1109/JIOT.2019.2957835

Monitoring ancient buildings: real deployment of an IoT system enhanced by UAVs and virtual reality

F.M. Bacco, P. Barsocchi, P. Cassarà, D. Germanese, A. Gotta, G.R. Leone, D. Moroni, M.A. Pascali, M. Tampucci
IEEE Access, vol. 8. IEEE, 2020.

The historical buildings of a nation are the tangible signs of its history and culture. Their preservation deserves considerable attention, being of primary importance from a historical, cultural, and economic point of view. Having a scalable and reliable monitoring system plays an important role in the Structural Health Monitoring (SHM): therefore, this paper proposes an Internet of Things (IoT) architecture for a remote

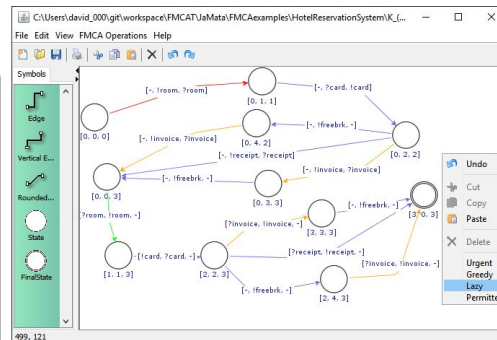
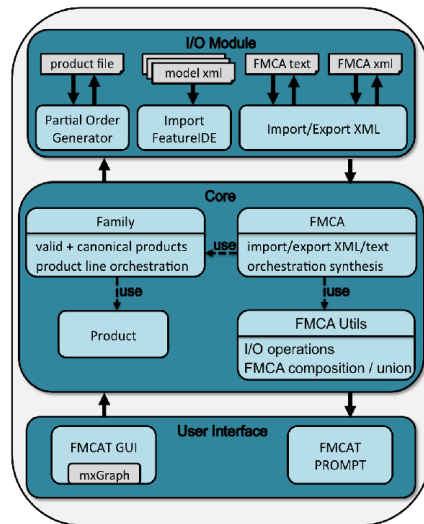
monitoring system that is able to integrate, through the Virtual Reality (VR) paradigm, the environmental and mechanical data acquired by a wireless sensor network set on three ancient buildings with the images and context information acquired by an Unmanned Aerial Vehicle UAV. Moreover, the information provided by the UAV allows to promptly inspect the critical structural damage, such as the patterns of cracks in the

structural components of the building being monitored. Our approach opens new scenarios to support SHM activities, because an operator can interact with real-time data retrieved from a Wireless Sensor Network (WSN) by means of the VR environment.

DOI: 10.1109/ACCESS.2020.2980359

Controller synthesis of service contracts with variability

D. Basile, M.H. ter Beek, P. Degano, A. Legay, G.-L. Ferrari, S. Gnesi, F. Di Giandomenico
 Science of Computer Programming, vol. 187. Elsevier, 2020.



On the left the architecture of the tool FMCAT and on the right a snapshot of the tool at work (see <https://github.com/davidebasile/FMCAT/blob/master/README.md>)

To model more fine-grained SLA and more adaptive service orchestrations, in this paper we endow contract automata with two orthogonal layers of variability: (i) at the structural level, constraints over service requests and offers define different configurations of a contract automaton, depending on which requests and offers are selected or discarded, and (ii) at the behavioural level, service requests of different levels of criticality can be declared, which induces the novel notion of semi-controllability. The synthesis of orchestrations is thus extended to respect both the structural and the behavioural variability constraints. Finally, we show how to efficiently compute the orchestration of all configurations from only a subset of these configurations. A prototypical tool supports the developed theory.

Service contracts characterise the desired behavioural compliance of a composition of services. Compliance is typically defined by the fulfilment of all service requests through service offers, as dictated by a given Service-Level Agreement (SLA). Contract automata are a recently introduced formalism

for specifying and composing service contracts. Based on the notion of synthesis of the most permissive controller from Supervisory Control Theory, a safe orchestration of contract automata can be computed that refines a composition into a compliant one.

DOI: 10.1016/j.scico.2019.102344

Spatial logics and model checking for medical imaging

F. Banci Buonamici, G. Belmonte, V. Ciancia, D. Latella, M. Massink
 International Journal on Software Tools for Technology Transfer, vol. 22. Springer, 2020.

Recent research on spatial and spatio-temporal model checking provides novel image analysis methodologies, rooted in logical methods for topological spaces. Medical imaging (MI) is a field where such methods show potential for ground-breaking innovation. Our starting point is SLCS, the Spatial Logic for Closure Spaces—closure spaces being a generalisation of topological spaces, covering also discrete space structures—

and topochecker, a model checker for SLCS (and extensions thereof). We introduce the logical language *ImgQL* (“Image Query Language”). *ImgQL* extends SLCS with logical operators describing distance and region similarity. The spatio-temporal model checker *topochecker* is correspondingly enhanced with state-of-the-art algorithms, borrowed from computational image processing, for efficient implementation of

distance-based operators, namely distance transforms. Similarity between regions is defined by means of a statistical similarity operator, based on notions from statistical texture analysis. We illustrate our approach by means of an example of analysis of Magnetic Resonance images: segmentation of glioblastoma and its oedema.

DOI: 10.1007/s10009-019-00511-9

Digital persona portrayal: identifying pluridentity vulnerabilities in digital life

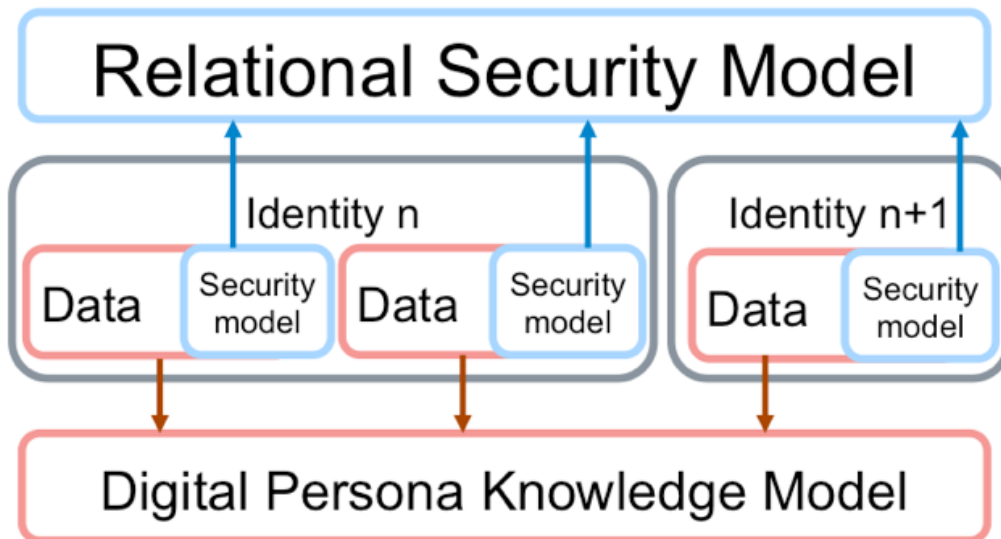
M.A. Olivero, A. Bertolino, F.J. Domínguez-Mayo, M. Escalona, I. Matteucci
 Journal of Information Security and Applications, vol. 52. ACM, 2020.

The increasing use of the Internet for social purposes enriches the data available online about all of us and promotes the concept of the Digital Persona. Nowadays, most of us possess more than one digital identity, what we define here as a Pluridentity. This trend brings though increased risks: it is well known that the security of a Digital Persona can be exploited if its data and security are not effectively managed. In this work, we focus specifically on a new type of digital attack that can be perpetrated by combining pieces of data belonging to one same Pluridentity in order to profile their target. Some victims can be so accurately depicted when looking at their Pluridentity that by using

the gathered information attackers can execute accurately personalized social engineering attacks, or even bypass otherwise safe security mechanisms. We characterize these Pluridentity attacks as a security issue of a virtual System of Systems, whose constituent systems are the individual identities and the humans themselves. We present a strategy to identify vulnerabilities caused by overexposure due to the combination of data from the constituent identities of a Pluridentity. To this end we introduce the Digital Persona Portrayal Metamodel, and the related Digital Pluridentity Persona Portrayal Analysis process: such model and process can be used to identify the vulner-

abilities of a Pluridentity due to its exploitation as a System of Systems. The approach has been validated on the Pluridentities of seventeen candidates selected from a data leak, by retrieving the data of their Digital Personae, and matching them against the security mechanisms of their Pluridentities. After analyzing the results for some of the analyzed subjects we could detect several vulnerabilities.

DOI: 10.1016/j.jisa.2020.102492



Data and security models dichotomy.

XACMET: XACML testing & modeling

S. Daoudagh, F. Lonetti, E. Marchetti
Software Quality Journal, vol. 28. Springer, 2020.

In the context of access control systems, testing activity is among the most adopted means to assure that sensitive information or resources are correctly accessed. In XACML-based access control systems, incoming access requests are transmitted to the Policy Decision Point (PDP) that grants or denies the access based on the defined XACML policies. The criticality of the PDP component requires an intensive testing activity consisting in probing such a component with a set of requests and checking whether its responses grant or deny the requested access as specified in the policy. Existing approaches for improving manual

derivation of test requests such as combinatorial ones do not consider policy function semantics and do not provide a verdict oracle. To fill this gap, we introduce XACMET, a novel approach for systematic generation of XACML requests as well as automated model-based oracle derivation. The main features of XACMET are as follows:

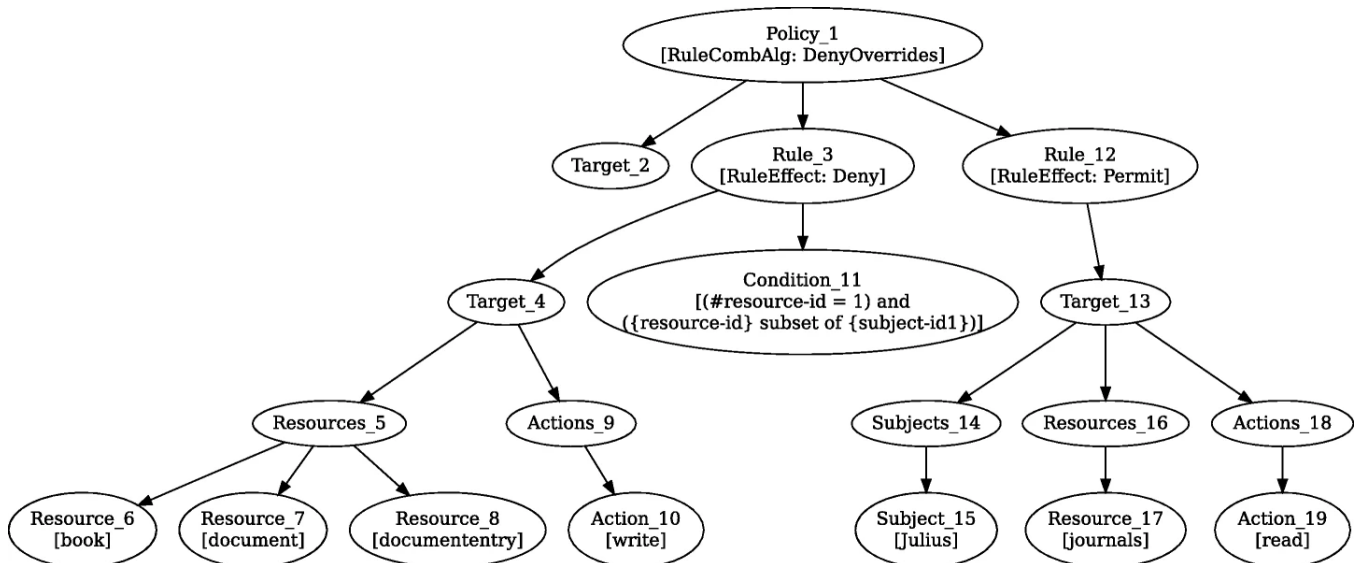
- (i) it defines a typed graph, called the XAC-Graph, that models the XACML policy evaluation;
- (ii) it derives a set of test requests via full-path coverage of this graph;

(iii) it derives automatically the expected verdict of a specific request execution by executing the corresponding path in such graph;

(iv) it allows us to measure coverage assessment of a given test suite.

Our validation of the XACMET prototype implementation confirms the effectiveness of the proposed approach.

DOI: 10.1007/s11219-019-09470-5



XAC-Tree. Label T_P means node of type T and parameter P. The attributes are within square brackets.

Flexible automatic support for web accessibility validation

G. Broccia, M. Manca, F. Paternò, F. Pulina

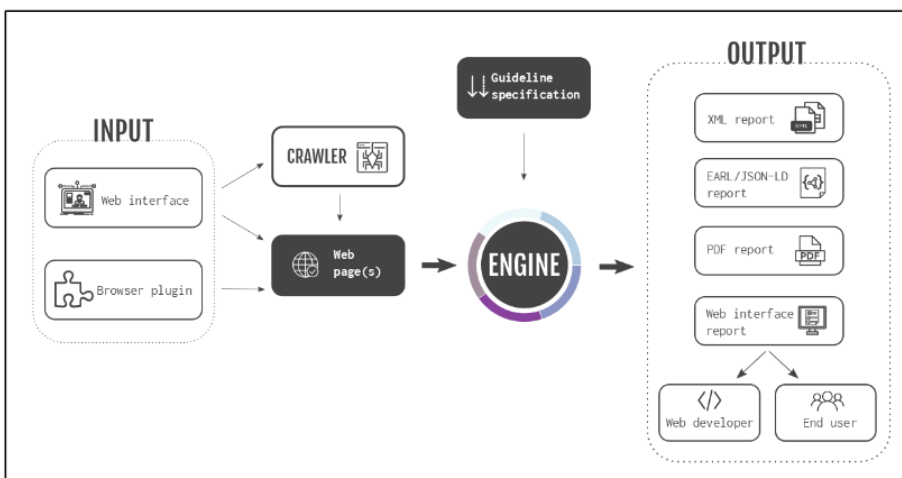
Proceedings of the ACM on Human-Computer Interaction, vol. 4. ACM, 2020.

Automatic support for web accessibility validation needs to evolve for several reasons. The increasingly recognised importance of accessibility implies that various stakeholders, with different expertise, look at it from different viewpoints and have different requirements regarding the types of outputs they expect. The technologies used to

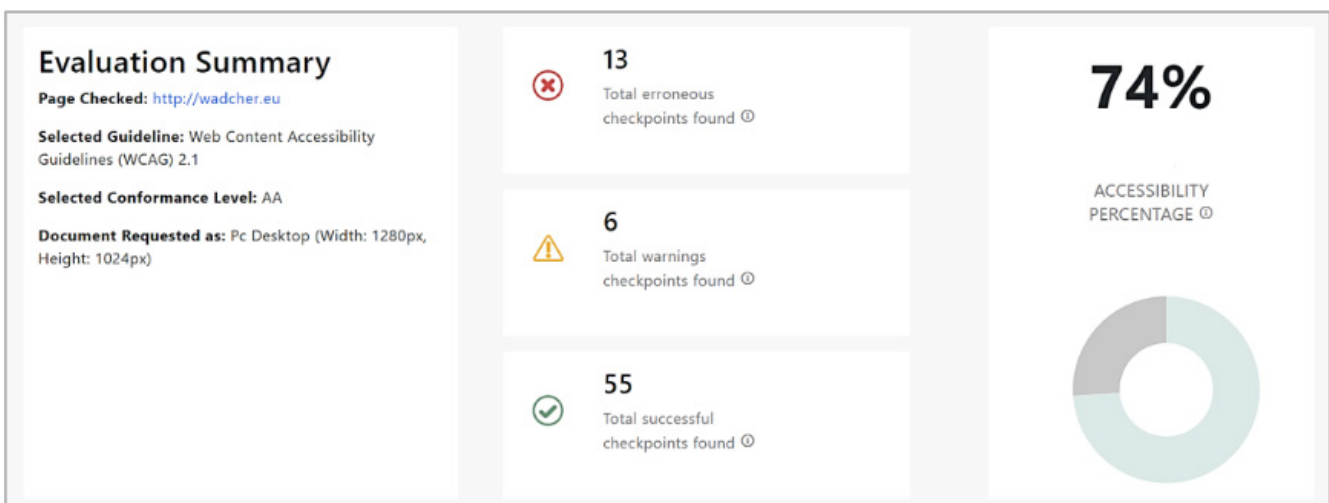
support Web application access are evolving along with the associated accessibility guidelines. We present a novel tool that aims to provide flexible and open support for addressing such issues. We describe the design of its main features including support for recent guidelines and tailored results presentations, and report on first technical

and empirical validations that have provided positive feedback

DOI: 10.1145/3397871



The proposed tool architecture.

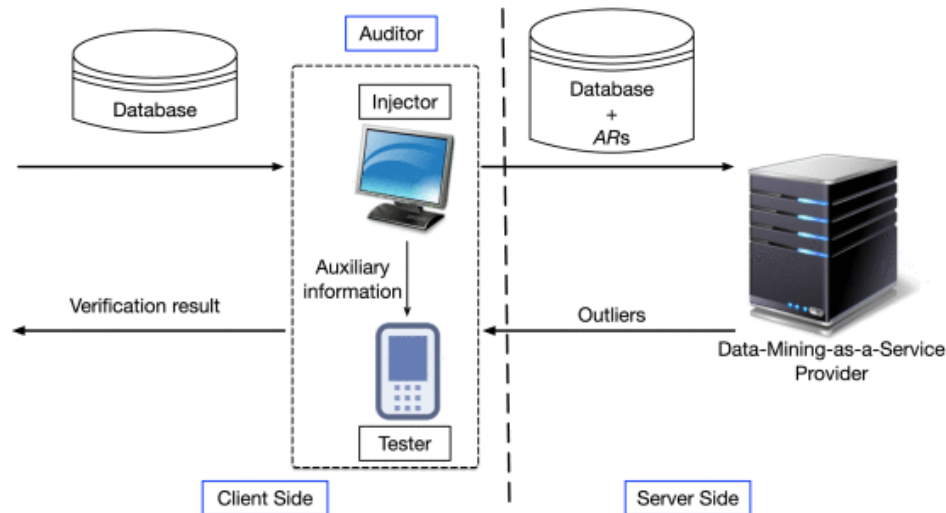


Tool Results Overview.

Authenticated outlier mining for outsourced databases

B. Dong, H. Wang, A. Monreale, D. Pedreschi, F. Giannotti, W. Guo

IEEE Transactions on Dependable and Secure Computing, vol. 17. IEEE, 2020.



The authentication architecture.

The Data-Mining-as-a-Service (DMaS) paradigm is becoming the focus of research, as it allows the data owner (client) who lacks expertise and/or computational resources to outsource their data and mining needs to a third-party service provider (server). Outsourcing, however, raises some issues

about result integrity: how could the client verify the mining results returned by the server are both sound and complete? In this paper, we focus on outlier mining, an important mining task. Previous verification techniques use an authenticated data structure (ADS) for correctness authentication, which may incur much space and communication cost. In this paper, we propose a novel solu-

tion that returns a probabilistic result integrity guarantee with much cheaper verification cost. The key idea is to insert a set of artificial records (ARs) into the dataset, from which it constructs a set of artificial outliers (AOs) and artificial non-outliers (ANOs). The AOs and ANOs are used by the client to detect any incomplete and/or incorrect mining results with a probabilistic guarantee. The main challenge that we address is how to construct ARs so that they do not change the (non-)outlierness of original records, while guaranteeing that the client can identify ANOs and AOs without executing mining. Furthermore, we build a strategic game and show that a Nash equilibrium exists only when the server returns correct outliers. Our implementation and experiments demonstrate that our verification solution is efficient and lightweight.

DOI: 10.1109/TDSC.2017.2754493

Exorcising the demon: angel, efficient node-centric community discovery

G. Rossetti

Studies in Computational Intelligence, vol. 881. Springer, 2020.

Community discovery is one of the most challenging tasks in social network analysis. During the last decades, several algorithms have been proposed with the aim of identifying communities in complex networks, each one searching for mesoscale topologies having different and peculiar characteristics. Among such vast literature, an interesting family of Community Discovery

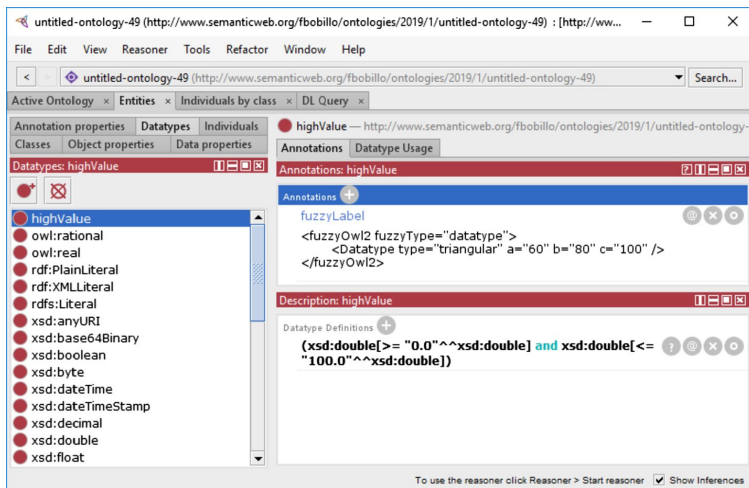
algorithms, designed for the analysis of social network data, is represented by overlapping, node-centric approaches. In this work, following such line of research, we propose Angel, an algorithm that aims to lower the computational complexity of previous solutions while ensuring the identification of high-quality overlapping partitions. We compare Angel, both on synthetic and re-

al-world datasets, against state of the art community discovery algorithms designed for the same community definition. Our experiments underline the effectiveness and efficiency of the proposed methodology, confirmed by its ability to constantly outperform the identified competitors.

DOI: 10.1007/978-3-030-36687-2_13

Fudge: fuzzy ontology building with consensuated fuzzy datatypes

I. Huitzil, F. Bobillo, J. Gomez-Romero, U. Straccia
Fuzzy Sets and Systems, *in press*. Elsevier, 2020.



Definition of the fuzzy datatype highValue using Fuzzy OWL 2.

An important problem in Fuzzy OWL 2 ontology building is the definition of fuzzy membership functions for real-valued fuzzy sets (so-called fuzzy datatypes in Fuzzy OWL 2 terminology). In this paper, we present a tool, called Fudge, whose aim is to support

the consensual creation of fuzzy datatypes by aggregating the specifications given by a group of experts. Fudge is freeware and currently supports several linguistic aggregation strategies, including the convex combination, linguistic OWA, weighted mean and fuzzy OWA, and easily allows to build others in. We also propose and have implemented two novel linguistic aggregation operators, based on a left recursive form of the convex combination and of the linguistic OWA.

DOI: 10.1016/j.fss.2020.04.001

Re-ranking via local embeddings: a use case with permutation-based indexing and the nSimplex projection

L. Vadicamo, C. Gennaro, F. Falchi, E. Chávez, R. Connor, G. Amato
Information Systems, *in press*. Elsevier, 2020.

Approximate Nearest Neighbor (ANN) search is a prevalent paradigm for searching intrinsically high dimensional objects in large-scale data sets. Recently, the permutation-based approach for ANN has attracted a lot of interest due to its versatility in being used in the more general class of metric spaces. In this approach, the entire database is ranked by a permutation distance to the query. Typically, permutations allow the efficient selection of a candidate set of results, but typically to achieve high recall or precision this set has to be reviewed using the original metric and data. This can lead to a sizeable percentage of the database being recalled, along with many expensive distance calculations.

To reduce the number of metric computations and the number of database elements accessed, we propose here a re-ranking based on a local embedding using the nSimplex projection. The nSimplex projection produces Euclidean vectors from objects in metric spaces which possess the n-point property. The mapping is obtained from the distances to a set of reference objects, and the original metric can be lower bounded and upper bounded by the Euclidean distance of objects sharing the same set of ref-

erences.

Our approach is particularly advantageous for extensive databases or expensive metric function. We reuse the distances computed in the permutations in the first stage, and hence the memory footprint of the index is not increased.

An extensive experimental evaluation of our approach is presented, demonstrating excellent results even on a set of hundreds of millions of objects.

DOI: 10.1016/j.is.2020.101506

Leveraging feature selection to detect potential tax fraudsters

T. Matos, J.A. Macedo, F. Lettich, J.M.Monteiro, C. Renso, R.Perego, F.M. Nardini
Expert Systems with Applications, vol. 145. Elsevier, 2020.

Enforcing the correct payment of taxes by taxpayers is fundamental for guaranteeing infrastructure investment and important services such as health-care, education and transportation. This issue is especially relevant in developing countries such as Brazil. In this work, we consider a real-world case study involving the Treasury Office of the State of Ceará which maintains a very large database containing information concerning more than 300,000 active taxpayers' companies. We address the problem of selecting the most relevant binary features to improve the classification of potential tax

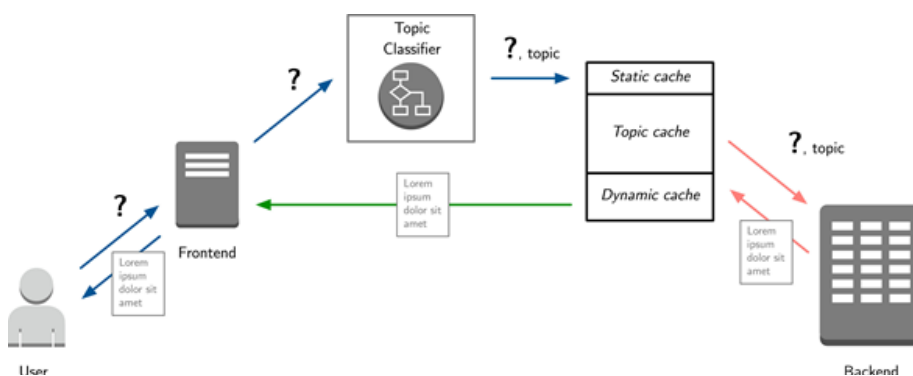
fraudsters. The task of finding out possible fraudsters from taxpayer data with binary features presents several challenges. First, taxpayer data typically have features with low linear correlation. Also, tax frauds may originate from intricate illicit tactics, which in turn requires to uncover non-linear relationships between multiple features. Finally, few features may be correlated with the target class. In this work, we propose ALICIA, a new feature selection technique based on association rules and propositional logic and on a carefully crafted graph centrality measure that attempts to tackle the above

challenges while, at the same time, being agnostic to specific classification techniques. We perform an extensive experimental evaluation to assess the validity of ALICIA on four different real-world datasets, where we compare our solution with eight other feature selection methods. The results show that ALICIA achieves F-measure scores up to 76.9%, and consistently outperforms its competitors.

DOI: 10.1016/j.eswa.2019.113128

Topical result caching in web search engines

I. Mele, O. Frieder, R. Perego, N. Tonello
Information Processing & Management, vol. 57. Elsevier, 2020.



Example of a search engine using the STD cache. The question mark represents the user query. In case of a hit in the cache, the results are returned to the user immediately (green arrow). Otherwise, a cache miss is encountered, and the request is sent to the back-end server (red arrows).

Caching search results is employed in information retrieval systems to expedite query processing and reduce back-end server workload. Motivated by the observation that queries belonging to different topics have different temporal-locality patterns, we investigate a novel caching model called STD (Static-Topic-Dynamic cache), a refinement of the traditional SDC

(Static-Dynamic Cache) that stores in a static cache the results of popular queries and manages the dynamic cache with a replacement policy for intercepting the temporal variations in the query stream. Our proposed caching scheme includes another layer for topic-based caching, where the entries are allocated to different topics (e.g., weather, education). The results of

queries characterized by a topic are kept in the fraction of the cache dedicated to it. This permits to adapt the cache-space utilization to the temporal locality of the various topics and reduces cache misses due to those queries that are neither sufficiently popular to be in the static portion nor requested within short-time intervals to be in the dynamic portion. We simulate different configurations for STD using two real-world query streams. Experiments demonstrate that our approach outperforms SDC with an increase up to 3% in terms of hit rates, and up to 36% of gap reduction w.r.t. SDC from the theoretical optimal caching algorithm.

The STD caching technique has been patented in the US on the 10/12/2019 (patent number 10503792).

DOI: 10.1016/j.ipm.2019.102193

Compressed indexes for fast search of semantic data

G.E. Pibiri, R. Perego, R. Venturini

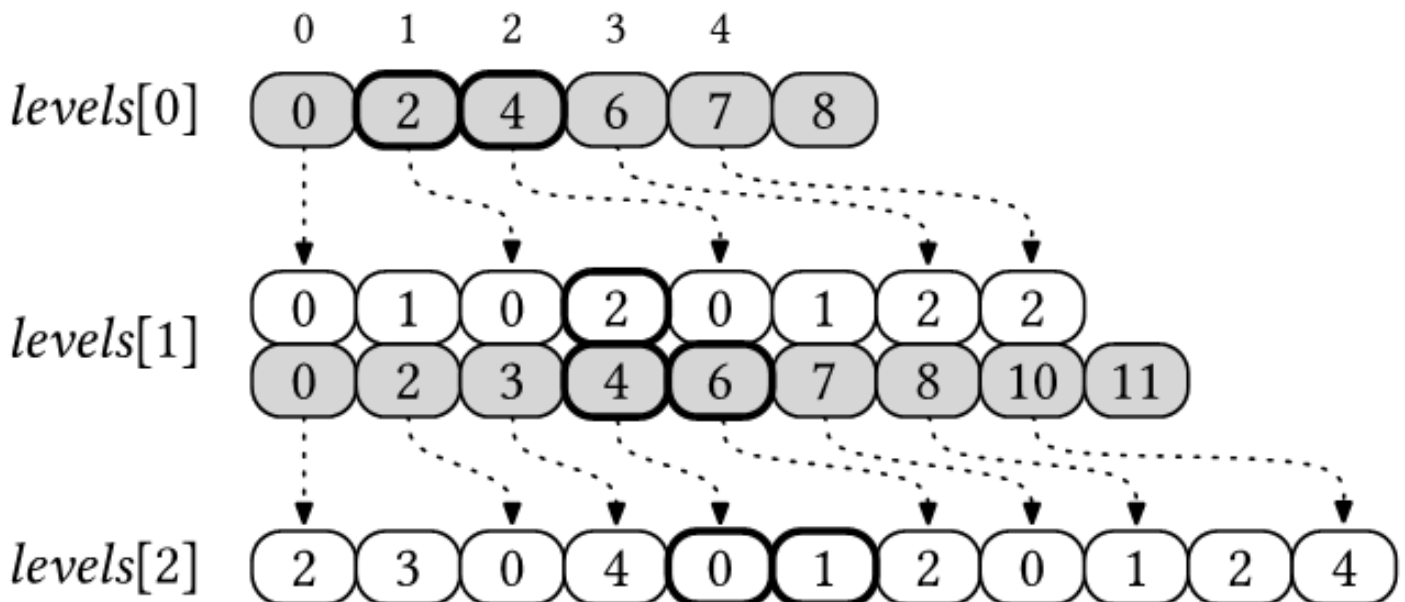
IEEE Transactions on Knowledge and Data Engineering. IEEE, 2020.

The sheer increase in volume of RDF data demands efficient solutions for the triple indexing problem, that is to devise a compressed data structure to compactly represent RDF triples by guaranteeing, at the same time, fast pattern matching operations. This problem lies at the heart of delivering good practical performance for the

resolution of complex SPARQL queries on large RDF datasets. In this work, we propose a trie-based index layout to solve the problem and introduce two novel techniques to reduce its space of representation for improved effectiveness. The extensive experimental analysis, conducted over a wide range of publicly available real-world datas-

ets, reveals that our best space/time trade-off configuration substantially outperforms existing solutions at the state-of-the-art, by taking 30 - 60% less space and speeding up query execution by a factor of 2-81x.

DOI: 10.1109/TKDE.2020.2966609



A trie data structure representing a set of RDF triples. Shaded boxes indicate pointers whereas the others refer to the nodes of the trie. Nodes in the first level are implicit, thus are not part of the data structure but reported here in smaller font for better visualization. Similarly, the dashed arrows are just for representational purposes and point to the position written in the corresponding originating box. Lastly, we highlight in thick stroke the nodes and pointers that are accessed during the resolution of the pattern (1, 2, ?).

Thermal vulnerability detection in integrated electronic and photonic circuits using infrared thermography

B. Hussain, B. Jalil, M.A. Pascali, M. Imran, G. Serafino, D. Moroni, P. Ghelfi
Applied Optics, vol. 59. OSA, 2020.

Failure prediction of any electrical/optical component is crucial for estimating its operating life. Using high temperature operating life (HTOL) tests, it is possible to model the failure mechanisms for integrated circuits. Conventional HTOL standards are not suitable for operating life prediction of photonic components owing to their functional dependence on the thermo-optic effect. This work presents an infrared (IR)-assisted thermal vulnerability detection technique suitable for photonic as well as electronic components. By accurately mapping the thermal

profile of an integrated circuit under a stress condition, it is possible to precisely locate the heat center for predicting the long-term operational failures within the device under test. For the first time, the reliability testing is extended to a fully functional microwave photonic system using conventional IR thermography. By applying image fusion using affine transformation on multimodal acquisition, it was demonstrated that by comparing the IR profile and GDSII layout, it is possible to accurately locate the heat centers along with spatial information on

the type of component. Multiple IR profiles of optical as well as electrical components/circuits were acquired and mapped onto the layout files. In order to ascertain the degree of effectiveness of the proposed technique, IR profiles of complementary metal-oxide semiconductor RF and digital circuits were also analyzed. The presented technique offers a reliable automated identification of heat spots within a circuit/system.

DOI: 10.1364/AO.389960

Optimized dislocation of mobile sensor networks on large marine environments using Voronoi partitions

M. D'Acunto, D. Moroni, A. Puntoni, O. Salvetti
Journal of Marine Science and Engineering, vol. 8. MDPI, 2020.

The real-time environmental surveillance of large areas requires the ability to dislocate sensor networks. Generally, the probability of the occurrence of a pollution event depends on the burden of possible sources operating in the areas to be monitored. This implies a challenge for devising optimal real-time dislocation of wireless sensor networks. This challenge involves both hardware solutions and algorithms optimizing the displacements of mobile sensor networks in

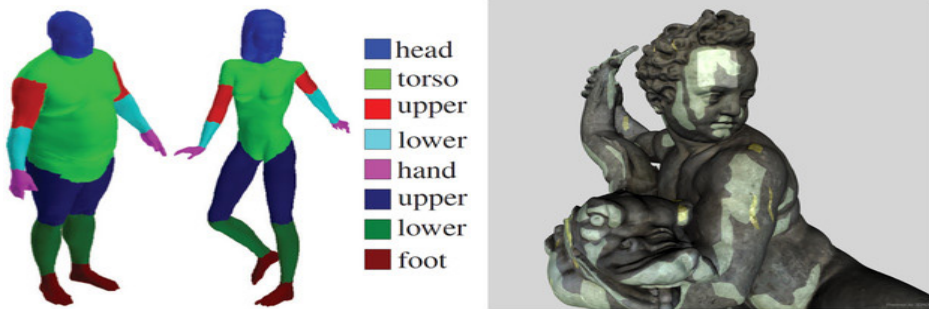
large areas with a vast number of sources of pollutant factors based mainly on diffusion mechanisms. In this paper, we present theoretical and simulated results inherent to a Voronoi partition approach for the optimized dislocation of a set of mobile wireless sensors with circular (radial) sensing power on large areas. The optimal deployment was found to be a variation of the generalized centroidal Voronoi configuration, where the Voronoi configuration is event-driven, and

the centroid set of the corresponding generalized Voronoi cells changes as a function of the pollution event. The initial localization of the pollution events is simulated with a Poisson distribution. Our results could improve the possibility of reducing the costs for real-time surveillance of large areas, and other environmental monitoring when wireless sensor networks are involved.

DOI: 10.3390/jmse8020132

Effective annotations over 3D models

F. Ponchio, M. Callieri, M. Dellepiane, R. Scopigno
 Computer Graphics Forum, vol. 39. Wiley, 2020.



Two examples of the different concepts of annotations. On the left, an example of semantic segmentation over a human shape, classifying the different body parts [KHS10]; on the right, an example of user-driven characterization of the surface which delimits some degraded regions and assigns them some textual annotations [ABC*18].

Annotation support in interactive systems is often considered a simple task by the CG community, since it entails the apparently easy selection of a region and its connection with some information. The reality appears more complex. The scope of this paper is two-fold: first, to review the status

of this domain, discussing and characterizing several approaches proposed in literature to manage annotations over geometric models; second, to present in detail an innovative solution proposed and assessed in the framework of Cultural Heritage (CH) applications, called ClippingVolumes . At

the annotation definition stage ClippingVolumes uses 3D data to characterize the annotation region; subsequently, annotations are visualized by adopting a two-pass rendering solution which uses stencil buffers, thus without introducing new geometric elements, changing the topology or duplicating geometry elements. It solves most of the issues that afflict the current state of the art, such as fragmentation, annotation transfer to multiple representations and multi-resolution data encoding. The latter is a mandatory requirement to produce efficient web-based systems. We implemented and we fully tested this approach in the framework of a complex system that supports the documentation of CH restoration projects.

DOI: 10.1111/cgf.13664

Turning a smartphone selfie into a studio portrait

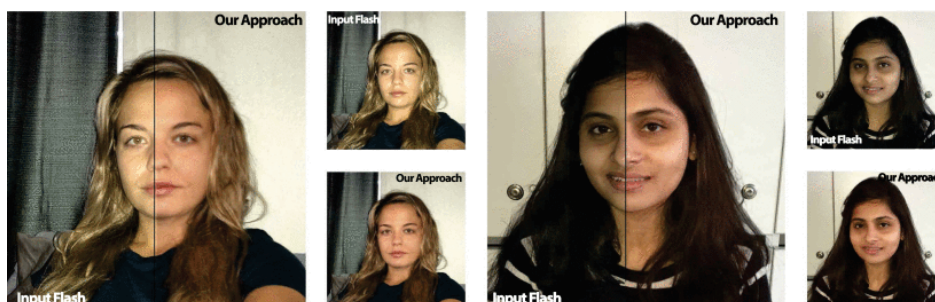
N. Capece, F. Banterle, P. Cignoni, F. Ganovelli, U. Erra, M. Potel
 IEEE Computer Graphics and Applications, vol. 40. IEEE, 2020.

We introduce a novel algorithm that turns a flash selfie taken with a smartphone into a studio-like photograph with uniform lighting. Our method uses a convolutional neural network trained on a set of pairs of photographs acquired in a controlled environment.

For each pair, we have one photograph of a subject's face taken with the camera flash enabled and another one of the same subject in the same pose illuminated using a photographic studio-lighting setup. We show how our method can amend lighting artifacts in-

troduced by a close-up camera flash, such as specular highlights, shadows, and skin shine.

DOI: 10.1109/MCG.2019.2958274



Two examples from our results. The split images show a comparison between the input and the output of our algorithm.

Long-term dynamic monitoring of medieval masonry towers

R.M. Azzara, M. Girardi, V. Iafolla, C. Padovani, D. Pellegrini
Frontiers in Built Environment. Frontiers Media, 2020.

The aim of the paper is to present and discuss the results of an ambient vibration monitoring campaign conducted in the old town of Lucca, over the period 2015–2018. Despite the low level of the ambient vibrations in the historic center, using high-sensitivity instrumentation allowed the authors to measure and study the dynamic behavior of two medieval masonry towers: the San Frediano belfry and the Clock Tower. The

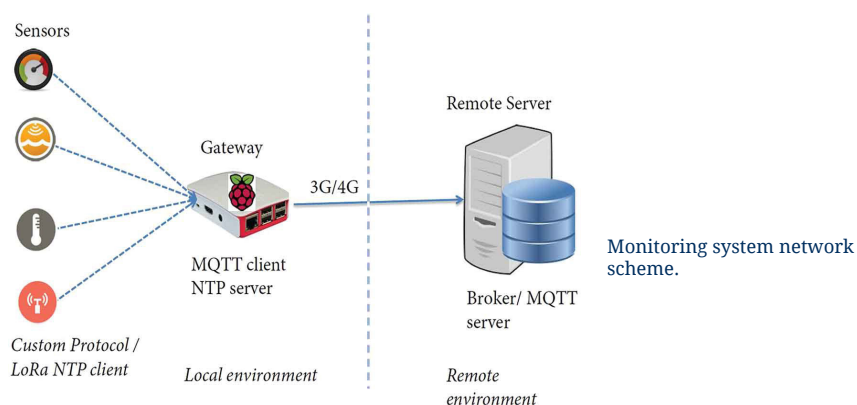
main results of the dynamic identification of the towers are summarized, together with the variation over time of their dynamic properties. Some insights on the towers' response to the anthropic activities in the historic center are also presented. Finally, a finite element simulation is performed with the aim of assessing the influence of temperature variations on the towers' natural frequencies; good agreement is found be-

tween numerical and experimental results. The paper provides the scientific and technical community with a detailed report on a singular experiment in the field of architectural heritage.

DOI: 10.3389/fbuil.2020.00009

Wireless sensor networks for continuous structural health monitoring of historic masonry towers

P. Barsocchi, G. Bartoli, M. Betti, M. Girardi, S. Mammolito, D. Pellegrini, G. Zini
International Journal of Architectural Heritage. Taylor & Francis, 2020.



tor network and the automatized procedure proposed for the continuous processing of the recorded signals are discussed and described with reference to an explicative masonry tower case study. It is believed that the proposed technologies can provide an economical and relatively non-invasive tool for real-time structural monitoring and that, moreover, the availability of large amounts of data from actual measurements can give effective information on the structural behaviour of historic constructions.

DOI: 10.1080/15583058.2020.1719229

The recent developments of micro-electro-mechanical systems and wireless sensor networks allow today the use of low-cost and small-size sensors for continuous monitoring of civil structures. Both these features are very important for the low impact of the sensor grid in heritage structures, ensuring a low-cost and sustainable dynamic monitoring system. Over the last 20 years the use of sensor networks for continuous monitoring has received a growing interest.

Anyway, still numerous questions remain opened about the sensitivity of measurement devices, the optimization of number and positioning of sensors, the energy efficiency of the network, and the development of algorithms for real-time data analysis. This paper, based on the aforementioned motivations, discusses about a monitoring system made of micro-electro-mechanical sensors connected through a wireless network. The architecture of the wireless sen-

Environmental sustainability of large satellite constellations in low earth orbit

C. Pardini, L. Anselmo

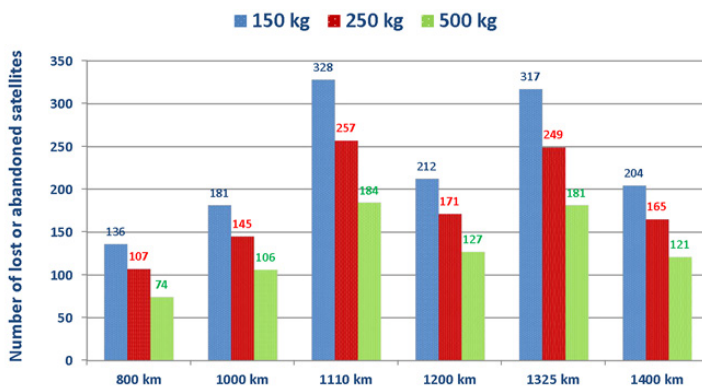
Acta Astronautica, vol. 170. Elsevier, 2020.

A specific criticality index, the collision rate percentage increase, was introduced in 2017 to assess the environmental impact of large satellite constellations in low Earth orbit (LEO). That index was estimated in this paper for various constellation arrangements, ranging in altitude from 800 km to 1400 km. The results obtained clearly show that in the regions of space where the current density of cataloged debris is already significant, such as around 800 km, just one hundred more abandoned satellites would increase the current collision rate by ~10%. In less congested LEO regions, as near 1110 km and 1325 km, a comparable increase in the collision rate could be achieved by a number of abandoned satellites between 200 and 500. Taking into account the new planned constellations from 800 km to 1400 km (consisting of approximately 6000 satel-

lites), an increase by nearly 20–30% of the total collision rate among cataloged objects in LEO might be expected, assuming an immediate spacecraft de-orbiting at the end-of-life, with a success probability of 90%. Of course, a greater number of satellites, as well as a reduced probability of successful disposal, would affect the environment even more negatively. Moreover, if the many disposed satellites were not de-orbited immediately, or in a relatively short time, the collision rate in LEO would further increase, at least in the medium term, unless the satellites do not continue to be controlled and maneuverable until they reenter the atmosphere. As an example, if a thousand satellites were disposed on elliptical orbits between 300 km and 1000 km, the collision rate among cataloged objects in LEO might grow by an additional 30% during the few

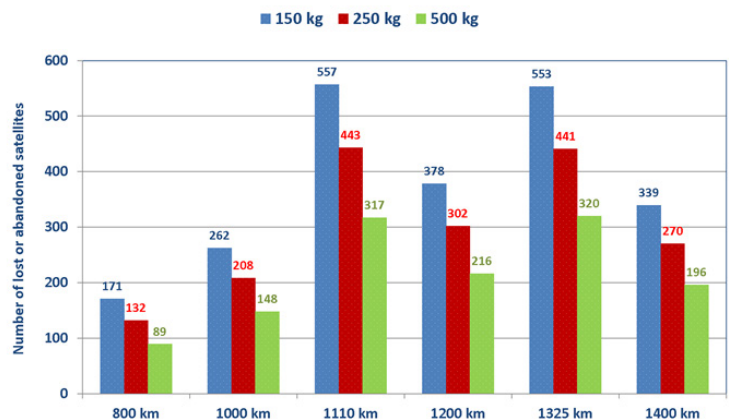
years needed to decay. That said, even assuming a willingness to endure a maximum 50% increase in the collision rate in LEO among objects greater than 10 cm, in the next 25 years, it is clear that an extended and expanded use of large constellations would be consistent with the environment sustainability only if it were possible to increase the post-mission disposal success probability to at least 95%, and hopefully to 99%. At the same time, the de-orbiting phase should be either quite short or fully controlled, in order to avoid the prolonged presence of several hundred or thousands of abandoned satellites in disposal orbits, further increasing the collision rate in low LEO.

DOI: 10.1016/j.actaastro.2020.01.016



(a) Number of satellites, abandoned in a shell 15 km thick around the constellation operational altitude, able to increase by 10% the total collision rate in LEO among cataloged objects, as a function of the spacecraft mass.

(b) Number of satellites, abandoned in a shell 50 km thick around the constellation operational altitude, able to increase by 10% the total collision rate in LEO among cataloged objects, as a function of the spacecraft mass.



A Digital Loggia for Raphael

ISTI-CNR and Art at the time of Coronavirus



At <http://vcg.isti.cnr.it/farnesina/loggia/>, you can observe at close distance both the beautiful stories of Cupid and Psyche, and the very particular pergola and animal species painted by Raphael and his assistants in Villa Farnesina, the Roman residence of Agostino Chigi, a wealthy banker and generous client of Raphael.

This interactive online system was projected and developed by Eliana Siotto and Gianpaolo Palma of the Visual Computing Lab, ISTI-CNR, in collaboration with Antonio Sgamellotti, Fellow of the National Lincei Academy, and Virginia Lapenta, Conservator of Villa Farnesina. The user can navigate freely within the “Log

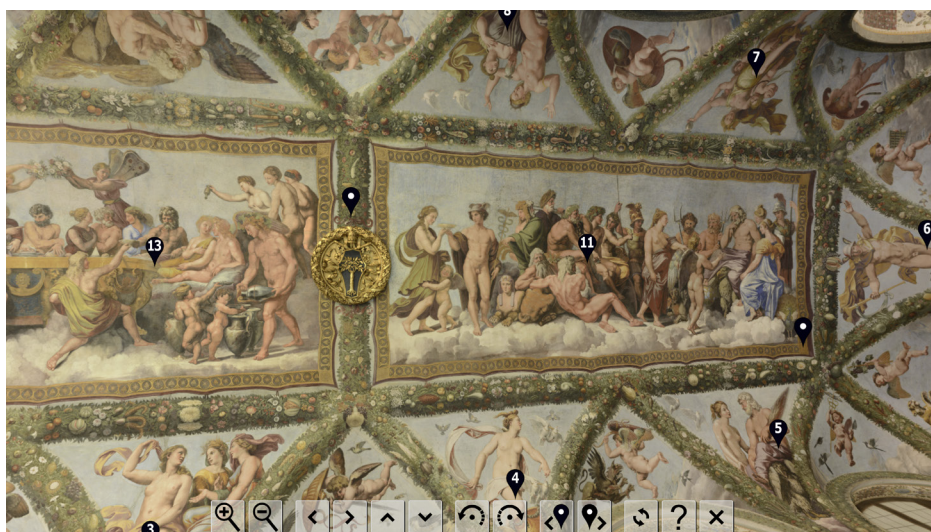
gia of Cupid and Psyche”, and study in detail the intricate frescoes of Raphael and his assistants Giulio Romano, Giovan Francesco Penni, and Giovanni da Udine: the so-called Raphael’s workshop.

The system allows the user to examine the figurative elements of the pictorial cycle enriched by historical and technical-artistic information. It is possible to identify the 170 vegetable species present within the festoons and the 50 animals represented in the spandrels of the vault. Pictorial details that would be challenging to observe in an actual visit to the Loggia (8 meters high) can be appreciated, and botanical, zoological, and iconographic

information plus results of non-invasive scientific analyses is readily accessible. The “Digital Loggia” is thus already available while it is necessary to wait before being able to admire once again the magnificence of Villa Farnesina in situ through two exhibitions organized by the National Lincei Academy as part of the celebrations on the fifth centenary of Raphael’s death: the “Raphael in Villa Farnesina: Galatea and Psyche” curated by Antonio Sgamellotti and his research group (October 6th, 2020 – January 6th, 2021), and “Raphael and the Antiquities in the Villa of Agostino Chigi” curated by Alessandro Zuccari, Lincei Fellow, and Costanza Barbieri, art historian, postponed to March 25th, 2021. The “Digital Loggia” is listed as one of the “136 projects to be reopened in Italy and globally” after many weeks of lockdown due to Coronavirus (<https://www.ilgiornaledellarte.com/articoli/il-giornale-dell-arte-di-maggio/133265.html>).

Thanks to a touchscreen kiosk, the “Digital Loggia” will remain accessible in the Loggia of Villa Farnesina after the end of the exhibitions in order to enhance enjoyment of the artistic masterpiece.

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<http://vcg.isti.cnr.it/farnesina/loggia/>



Grants for young mobility

Winners 2019

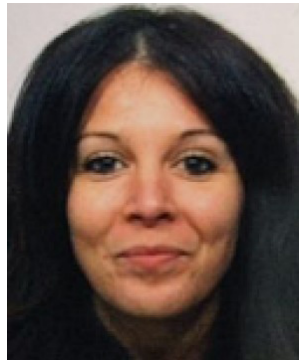
The ISTI Grants for Young Mobility (GYM) program enables young researchers (below 34) to carry out research in cooperation

with foreign Universities and Research Institutions of clear international standing.

It complements similar CNR programs.



Luca Ciampi



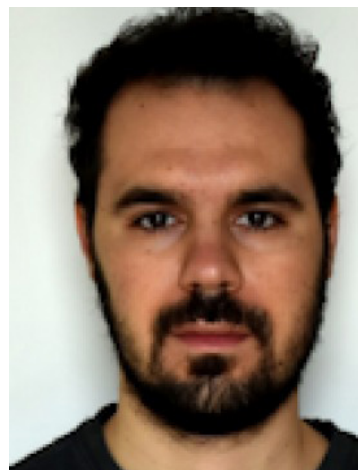
Danila Germanese



Maria Giovanna Masciotta



Fabio Valerio Massoli



Nicola Messina

New Deputy Chair of the IADC Working Group on Environment and Data Base

Carmen Pardini appointed at the spring Steering Group Meeting

On 9 April 2020, during the Steering Group conference call that replaced the 38th Plenary Meeting of the Inter-Agency Space Debris Coordination Committee (IADC), to be held in Toulouse, France, from 6 to 10 April, Carmen Pardini was appointed Deputy Chair, for a two-year term, of the Working Group 2, mainly in charge of the characterization and modelling of meteoroid and debris around the Earth, and storage and access of the data by electronic means.

The IADC is the main international governmental forum for the worldwide coordination of activities related to the issues of human-made and natural debris in space. Currently consisting of 13 space agencies, its primary purposes are to exchange technical information on space debris research activities, to facilitate opportunities for

cooperation in space debris research, to review the progress of ongoing cooperative activities, and to identify debris mitigation options. It also plays a prominent role in advising the international community, for instance the Committee on the Peaceful Uses of Outer Space (COPUOS) of the United Nations.

In the new position, Carmen, a staff researcher of the Space Flight Dynamics Laboratory, will support the coordination of the activities of the Working Group 2 during a period characterized by great changes in space activities and new challenges in debris mitigation.



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<https://www.iadc-home.org/>

Fabio Paternò has been recognized as an IFIP Fellow



IFIP (International Federation of Information Processing) has announced its first cohort of Fellows, elevating 18 Members to the new higher status in recognition of their substantial and enduring contributions in the ICT field.

One of them is Fabio Paternò, Research Director at ISTI-CNR, where he leads the Laboratory on Human Interfaces in Infor-

mation Systems. He was recognized for his numerous contributions to Human Computer Interaction (HCI) with implications for connected fields such as Software Engineering and Artificial Intelligence.

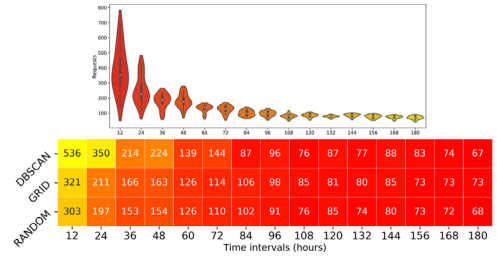
<https://www.ifipnews.org/ifip-names-first-cohort-fellows-2/>

Best paper award - ISCC 2019

IEEE Symposium on Computers and Communications, June 30 - July 3, 2019 Barcelona, Spain

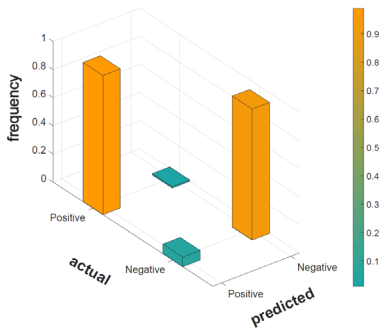
Best Paper Award for the paper "Selection of Mobile Edges for a Hybrid CrowdSensing Architecture" by Dimitri Belli, Stefano

Chessa, Antonio Corradi, Giampiero Di Paolo, Luca Foschini, Michele Girolami.



Best paper award - IE 2019

15th International Conference on Intelligent Enviroments, 24-27 June 2019 Rabat, Morocco



The paper "Remote Detection of Indoor Human Proximity using Bluetooth Low Energy Beacons" written by Fabio Mavilia,

Paolo Barsocchi, Stefano Chessa, Michele Girolami, received recognition as "Best Paper" at the IE International Conference.

Six HPC Lab papers at ACM SIGIR 2020

HPC Lab is proud to have six papers accepted at ACM SIGIR 2020, the major international forum for the presentation of new research results in the field of information retrieval (IR).

They are on hot research topics including neural IR, conversational search, and learning to rank. Below the references and the links to preprints available on arXiv.

"Efficient Document Re-Ranking for Transformers by Precomputing Term Representations", by Sean MacAvaney, Franco Maria Nardini, Raffaele Perego, Nicola Tonellotto, Nazli Goharian, Ophir Frieder. Accepted as a full paper at #SIGIR2020. Preprint available here: <http://arxiv.org/abs/2004.14255>.

"Training Curricula for Open Domain Answer Re-Ranking", by Sean MacAvaney,

Franco Maria Nardini, Raffaele Perego, Nicola Tonellotto, Nazli Goharian, Ophir Frieder. Accepted as a full paper at #SIGIR2020. Preprint available here: <http://arxiv.org/abs/2004.14269>.

"Expansion via Prediction of Importance with Contextualization" by Sean MacAvaney, Franco Maria Nardini, Raffaele Perego, Nicola Tonellotto, Nazli Goharian, Ophir Frieder. Accepted as a short paper at #SIGIR2020. Preprint available here: <http://arxiv.org/abs/2004.14245>.

"Topic Propagation in Conversational Search" by Ida Mele, Cristina I. Muntean, Franco Maria Nardini, Raffaele Perego, Nicola Tonellotto, Ophir Frieder. Accepted as a short paper at #SIGIR2020. Preprint available here: <http://arxiv.org/abs/2004.14054>.

"Query-level Early Exit for Additive Learning-to-Rank Ensembles" by Claudio Lucchese, Franco Maria Nardini, Salvatore Orlando, Raffaele Perego, Salvatore Trani. Accepted as a short paper at #SIGIR2020. Preprint available here: <https://arxiv.org/abs/2004.14641>.

"Efficient and Effective Query Auto-Completion", by Giulio Ermanno Pibiri, Simon Gog, Rossano Venturini. Accepted as a full paper at the industry track of #SIGIR2020 (joint work with eBay). Preprint available here: <http://pages.di.unipi.it/pibiri/papers/SIGIR20.pdf>.

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Pervasive Artificial Intelligence Lab

PAI Lab, a joint initiative by CNR and University of Pisa

In January, the Institute of Computer Science and Technologies of the Italian National Research Council (ISTI-CNR) and the Department of Computer Science of the University of Pisa (CS@UNIFI) stipulated an agreement to establish a research laboratory operating at international level and focussed on topics related to Artificial Intelligence and Pervasive Computing: the Pervasive Artificial Intelligent (PAI) Lab. Both CS@UNIFI and ISTI-CNR are currently lavishing much research effort in topics related to these two key areas.

The Pervasive Artificial Intelligence Lab intends to investigate the following fields:

- 1) Design and development of algorithms, models and software for AI and Machine Learning (ML);
- 2) Algorithms, software and hardware platforms for high-performance and scalable processing of AI and ML models;
- 3) Distributed and embedded artificial intelligence and learning;

- 4) Distributed and in-silico neural computation;
- 5) Federated learning;
- 6) Cybersecurity in machine learning;
- 7) Learning on streaming data and continual learning;
- 8) Methods, algorithms and systems for human-aware, secure and safe AI in pervasive computing scenarios;
- 9) Intelligent Internet-of-Things (IoT) and cyberphysical systems;
- 10) AI-on-Cloud, AI-for-the-Cloud, AlaaS;
- 11) Learning at-the-edge.

In addition to supporting specific research activities, the Pervasive Artificial Intelligence Laboratory aims at:

- a) Enabling enhanced technology transfer for AI and pervasive computing related topics through improved knowledge exchange and resource sharing;

- b) Optimizing fund-raising opportunities, especially in the European context, related to the topics targeted by the laboratory;
- c) Creating opportunities for training young researchers in AI and pervasive computing related topics;
- d) Organizing courses of specialization for (under-)graduate students and practitioners interested in topics related to Pervasive Artificial Intelligence;
- e) Acting as a competence center supporting SMEs, Digital Innovation Hubs and other institutions for all the topics covered by the laboratory;
- f) Organizing events to communicate and disseminate results.

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Davide Bacciu



Patrizio Dazzi

FlexMaps 2.0: a bending active structure with optimized spiral mesostructures



Bending-active structures are an inexpensive and efficient structural system that can produce curved shapes out of flat or straight elements. In this context, the FlexMaps algorithm [Malomo et al. 2018] has demonstrated good performance in generating complex-shaped, efficient, and lightweight structures [Laccone et al. 2019].

The FlexMaps algorithm relies on locally optimizing mesostructured panels, namely spiral patterns that can bend to assume double curvature.

The stiffness of a panel can be tuned by modifying the geometry of each spiral. The pattern is optimized to match the target shape once assembled. Thus, even non-developable complex shapes can be segmented and made out of flat panels.

The strengths of these systems lie in spiral geometry, which can produce bespoke panels with a tuned stiffness by only modifying the geometrical parameters without changing the material. Having a spiral path rather than a linear path results in less bending stress while obtaining the same curvature.

Recently, a new project, which aims at consolidating the use of FlexMaps in advanced architectural design, has automated the workflow that links shape design to digital fabrication. This workflow includes shape design, optimization, structural verification, 2D layout design and digital fabrication.

The demonstrator of this method is shown in the photos and has been built at the School of Architecture (Faculty of Design, Architecture and Building, DAB) of the University

of Technology Sydney. It has been entirely fabricated at the Advanced Fabrication Lab by machine milling 15 mm plywood sheets. This research project demonstrates how FlexMaps can be efficiently integrated into a real-scale architectural production process and adapted to the complexity of contemporary design.

Project Team

ISTI-CNR: Francesco Laccone, Luigi Malomo and Paolo Cignoni

UTS School of Computer Science [FEIT]: Nico Pietroni

UTS School of Architecture [DAB]: Dane Voorderhake, Lucy Wang, Nathan Gonsalves and Tim Schork

Credits

The demonstrator has been entirely fabricated at the Advanced Fabrication Lab of the UTS School of Architecture. It has been assembled by 4-5 people in about 2 days, and exhibited at The Space (DAB, UTS Building 6) from February 24, 2020 to March 06, 2020. It was then disassembled and reassembled on the Ground Floor of FEIT (UTS, Building 11) where it is currently located.

Funding

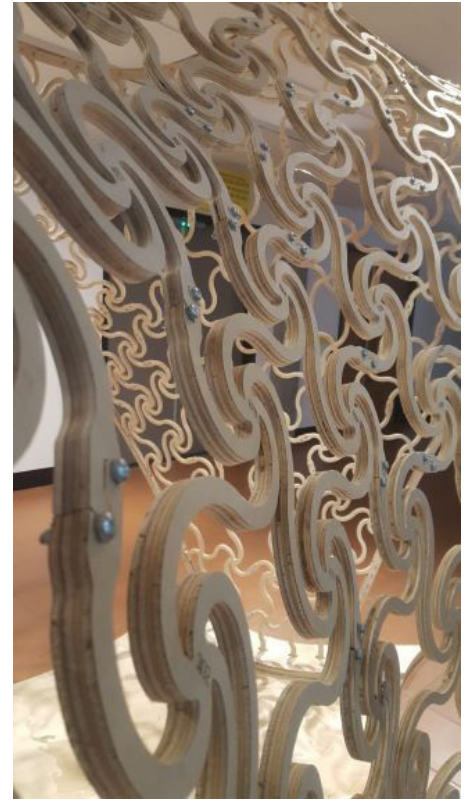
This research was partially developed during the Short Term Mobility of Francesco Laccone, hosted by Nico Pietroni at the UTS. The STM scholarship was founded by CNR (prot. 0071741/2019 of 17/10/2019).

Research Products

Luigi Malomo, Jesús Pérez, Emmanuel Iarussi, Nico Pietroni, Eder Miguel, Paolo Cignoni, Bernd Bickel "FlexMaps: Computational Design of Flat Flexible Shells for Shaping 3D Objects" ACM Trans. on Graphics - Siggraph Asia 2018, Volume 37, Number 6, page 14 - nov 2018 <http://vcg.isti.cnr.it/Publications/2018/MPiPMCB18/>).

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Ph.D. dissertations

Edge selection strategies for human-enabled sensing architectures

Author: Dimitri Belli, Dipartimento di Informatica, Università di Pisa
Supervisors: Stefano Chessa, Michele Girolami

This thesis focuses on synergies between Mobile CrowdSensing (MCS) and Multi-access Edge Computing (MEC). Specifically, the thesis proposes a social mobile edge architecture composed by interoperable fixed (FMEC) and mobile (M2EC) units in the MEC middleware layer. After introducing a method of task assignment based on MCS mobile resources, the thesis proposes some optimization methods to share contents between users leveraging their mobility and sociabil-

ity. The central part of the thesis presents an algorithm for the selection of M2ECs to be used in synergy and/or in places of the fixed ones. The M2EC social-aware selection algorithm is performed by leveraging the links between users and the fact that they tend to form cohesive communities. The thesis proposes two selection criteria: the first one is based on the users' sociability, while the second criteria exploits the attitude of the users in performing the assigned tasks. The

last part of the thesis introduces a probabilistic model for the estimation of the optimal number of M2ECs to be selected in order to achieve a specific coverage. The thesis also includes a comprehensive evaluation of the performance that can be obtained by combining FMECs and M2ECs. The solutions proposed have been tested with a real-world MCS dataset which provides meaningful mobility traces of students in urban areas for over one year of data collection.

Just-in-time adaptive anomaly detection and personalized health feedback

Author: Parvin Parvaneh, Dipartimento di Informatica, Università di Pisa
Supervisors: Fabio Paternò, Stefano Chessa

The rapid population aging and the availability of sensors and intelligent objects motivate the development of information technology-based healthcare systems that meet the needs of older adults by supporting them to continue their day-to-day activities. These systems collect information regarding the daily activities of the users that potentially helps to detect any significant changes and to provide them with relevant and tailored health-related information and quality of life-improving suggestions.

We propose a Just-in-time adaptive intervention system that models the user daily routine using a task model specification

and detects relevant contextual events that occurred in their activity in order to detect anomalous behaviors and strategically generate tailored interventions to encourage behaviors conducive to a healthier lifestyle.

The system uses a novel algorithm to detect anomalies in the user daily routine. In addition, by a systematic validation through a system that automatically generates wrong sequences of activities, we show that our anomaly detection algorithm is able to find behavioral deviations from the expected behavior at different times along with the category of the anomalous activity performed by the user with good accuracy.

Later, the system uses a Mamdani-type fuzzy rule-based component to predict the level of intervention needed for each detected anomaly and a sequential decision-making algorithm, Contextual Multi-armed Bandit, to generate suggestions to minimize anomalous behavior. We describe the system architecture in detail, and we provide example implementations for corresponding health feedback. To test our approach, we collected sensor data in our smart lab testbed while an actor was performing activities of daily living over a period of 2 weeks.

Modeling & predicting privacy risk in personal data

Author: Roberto Pellungrini, Dipartimento di Informatica, Università di Pisa
Supervisors: Anna Monreale, Dino Pedreschi

Privacy in Big Data analytics is one of the most important issues that analysts and businesses face when managing personal data. In a privacy preserving analysis process, the privacy risk on the individuals represented in the data is firstly evaluated, then the data is appropriately modified in order to preserve privacy while at the same time

maintaining a certain level of data quality. In this thesis we focus on privacy risk assessment, proposing new models and algorithms to deal with this fundamental part of privacy aware systems. We propose some extensions to an existing state-of-the-art privacy risk assessment framework, to improve on existing literature. Then, we propose a clas-

sification based methodology to predict privacy risk. We validate our proposal on three different types of real world data: human mobility, retail and social network data. Finally we propose a new model for the behavior of an adversary in human mobility data, leveraging the natural structure and constraints of this kind of data.

Efficiency-effectiveness trade-offs in modern query processing

Author: Roberto Trani, Dipartimento di Informatica, Università di Pisa
Supervisors: Rossano Venturini, Franco Maria Nardini

Modern search engines face enormous performance challenges. The most popular ones process tens of thousands of queries per second and manage billions of documents. Besides being efficient in processing the queries, they have also to be effective in satisfying the information needs of the users. However, techniques that improve the quality of the results can also require longer processing time. Search engines have thus often to attain a compromise between effectiveness and efficiency when employing new query processing solutions. In this thesis, we propose three new solutions for improving the efficiency-effectiveness trade-offs in several different tasks of modern query processors, namely: query expansion, search results filtering, and top-1 retrieval.

Query expansion is the task of augmenting the user query with additional terms so

to overcome some of the difficulties arising from natural language, such as synonymy and polysemy. We propose a thesaurus-based query expansion framework relying on structured Conjunctive Normal Form queries. We also propose three novel term selection supervised models capturing efficiency and effectiveness of the expansion candidates to include into the expanded query.

Search results filtering refers to the task of discarding some search results from an attribute-sorted list, e.g., by recency or by price, to improve the effectiveness of the returned results while preserving the ordering. For this purpose, we propose one efficient optimal algorithm and one faster approximate algorithm with strong approximation guarantees, which enable filtering in scenarios with tight time constraints.

Top-1 retrieval regards the identification of the utmost relevant result. It is critical in many applications, such as conversational AI and question answering, returning only one utmost relevant result to each user query. We propose an efficient algorithm for finding the result obtaining the highest number of pairwise comparisons, given by a pairwise machine learning classifier, while performing the minimum number of comparisons needed to solve this problem. In this thesis, we show that by trading efficiency for effectiveness it is possible to achieve a huge improvement of efficiency on these tasks at the cost of a negligible loss of effectiveness. We also demonstrate that new efficient algorithms can enable effective yet inefficient techniques to be efficiently used, thus providing new appealing solutions in the efficiency-effectiveness trade-off space.

Superdiversity(Big)Data analytics at the crossroads of geography, language and emotions

Author: Laura Pollacci, Dipartimento di Informatica, Università di Pisa
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In a series of articles, Vertovec focused on the changes and contexts that have affected migratory flows around the world. These demographic changes, which Vertovec defines Superdiversity, are the result of the globalisation and they outline a change in the overall level of migration patterns. Over time, the migration routes have increased both their diversity and complexity. The nature of immigration has brought with it a transformative “diversification of diversity”. Strictly connected with ethnicity and Superdiversity studies, the phenomenon of human migration has been a constant during human history.

In the era of Big Data, every single user lives in a hyper-connected world. More than 75% of the world’s population has a mobile phone, and over half of these are smartphones. The

use of social media grows together with the number of connected people.

In these social Big data, User-Generated Content incorporate a high number of discriminating information. Language, space and time are three of the best features that can be employed to detect Superdiversity. The strongest point of social Big Data is that they typically natively include various information about different dimensions.

Starting from these observations, in this thesis, we define a measure of Superdiversity, a Super-diversity Index, by adding the emotional dimension and placing it in the context of social Big Data. Our measure is based on an epidemic spreading algorithm that is able to automatically extend the dictionary used in lexicon-based sentiment analysis. It is eas-

ily applicable to various languages and suitable for Big Data. Our Superdiversity Index allows for comparing diversity from the point of view of the emotional content of language in different communities.

An important characteristic of our Superdiversity Index is the high correlation with immigration rates. For this reason, we believe this can be used as an essential feature in a nowcasting model of migration stocks. Our framework can be applied with higher time and space resolution compared to official statistics. Moreover, we apply our method to a different context and data to measure the Superdiversity of the music world.

Welcome aboard!



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