CENTER FOR ADVANCED STUDIES, RESEARCH AND DEVELOPMENT IN SARDINIA

CRS4
IDEAS BECOME LIFE
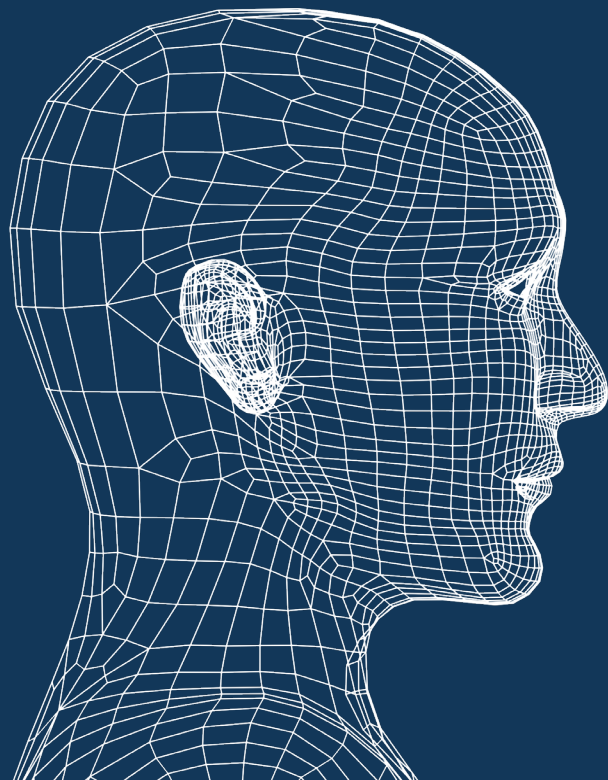
CRS4, Center for Research, Development and Advanced Studies in Sardinia, was established in 1990 by the Region of Sardinia. It is currently a limited liability consortium with the regional agency Sardegna Ricerche as sole shareholder and administrator of the Sardinian Science and Technology Park, where the Center's legal office is located.

RESEARCH & DEVELOPMENT OF ENABLING TECHNOLOGIES

- BIOSCIENCES AND COMPUTATIONAL INFRASTRUCTURES, SMART PROJECTS
- DIGITAL TECHNOLOGIES FOR AEROSPACE
- HPC FOR ENERGY AND ENVIRONMENT
- ICT - INFORMATION SOCIETY
- VISUAL AND DATA INTENSIVE COMPUTING
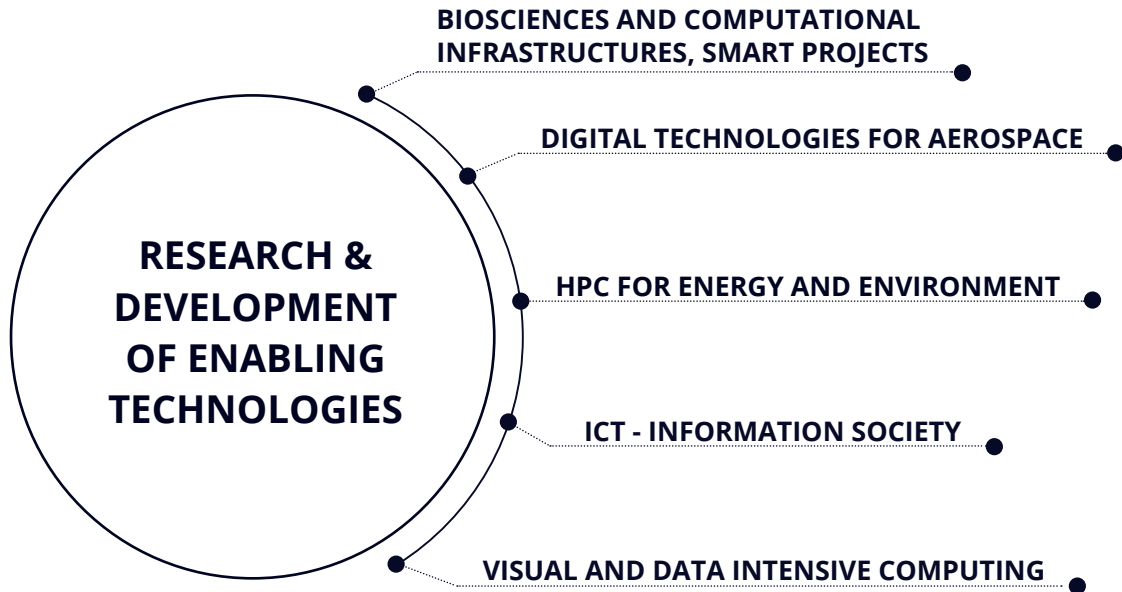
BIOSCIENCES AND COMPUTATIONAL INFRASTRUCTURES, SMART PROJECTS

The sector manages and develops CRS4's IT systems and platforms to guarantee high-performance computing (HPC) and ICT services with the aim of meeting the multiple needs of the research community, inside and outside the Science and Technology Park of Sardinia. Activities are focused on the study of next-generation infrastructures, Urban Computing and high-performance networks. The main objective is to develop innovative projects and platforms connecting the world of research and business with state-of-the-art technological solutions. Research focuses on the efficient management of operational scenarios in a wide range of topics, such as Smart Cities, public safety and emergency management, and DNA analyses.

HIGH PERFORMANCE COMPUTING

This program provides support to researchers, external users and industry in terms of computing services. High-performance computing platforms enable the use of techniques for numerical modelling, making a significant contribution to the advancement of the knowledge-base and the creation of technologically advanced products and processes. The infrastructures make it possible to design, study, reproduce and visualise complex natural phenomena and engineering systems with great accuracy. High-performance computing is used for meteorology, geophysics, fluid dynamics, the study of matter in chemistry, the development of molecules for new drugs, the analysis of proteins in medicine and genetic data.

SECURITY AND NETWORKS

Digital Security plays a key role in protecting user data including that produced by research and industrial projects. To guarantee data security, the group applies the most solid and recognised best practices and the latest technologies available on the market. The programme is also responsible for the design and implementation of networks where there are specific needs in terms of latency, bandwidth or other specific characteristics – using the experience gained in the management and development of complex networks, from the computer centre and with the latest wireless networks, providing high bandwidth capacity, as well as in optical transport networks, based on wavelength-division multiplexing (xWDM) technology.

IT SERVICES

The programme here designs, manages and develops CRS4's IT service delivery platforms with the aim of fulfilling the various needs of the centre's users, providing first and second level IT support to CRS4 researchers and administrative staff. The IT services take care of the routine functioning of the e-mail, the versioning services, the data backup platform, the storage servers hosting the employees' data and the infrastructure necessary to connect the workstations to the internal and external network. The programme is also engaged in maintaining the state-of-the-art infrastructure and the continuous updating of server and workstation software to protect against cyber attacks.

SMART PROJECT DEVELOPMENT

The purpose of this programme is to develop innovative projects and platforms to create a link between research and the business world as well as to transfer the technological expertise to industry by offering state-of-the-art smart solutions, in order to stimulate the growth process within SMEs. The research focuses on the efficient management of operational scenarios that cover different areas, such as Smart Cities, public safety and emergency management.

QUANTUM COMPUTING

This group brings together experts in physical modelling, programming, scientific communication and computer science, with the aim of studying the characteristics of quantum computation, in order to more effectively solve large-scale optimisation and research problems involving large amounts of data. The programme also aims to make quantum computing accessible to CRS4 groups and to other companies, in their own specific field of technological application. The research activity will exploit the so-called quantum advantage, which is now emerging in multiple subject areas, in order to solve problems that are considered untreatable with conventional hardware.

HPC
SUPPORT & SERVICES

High Performance Computing
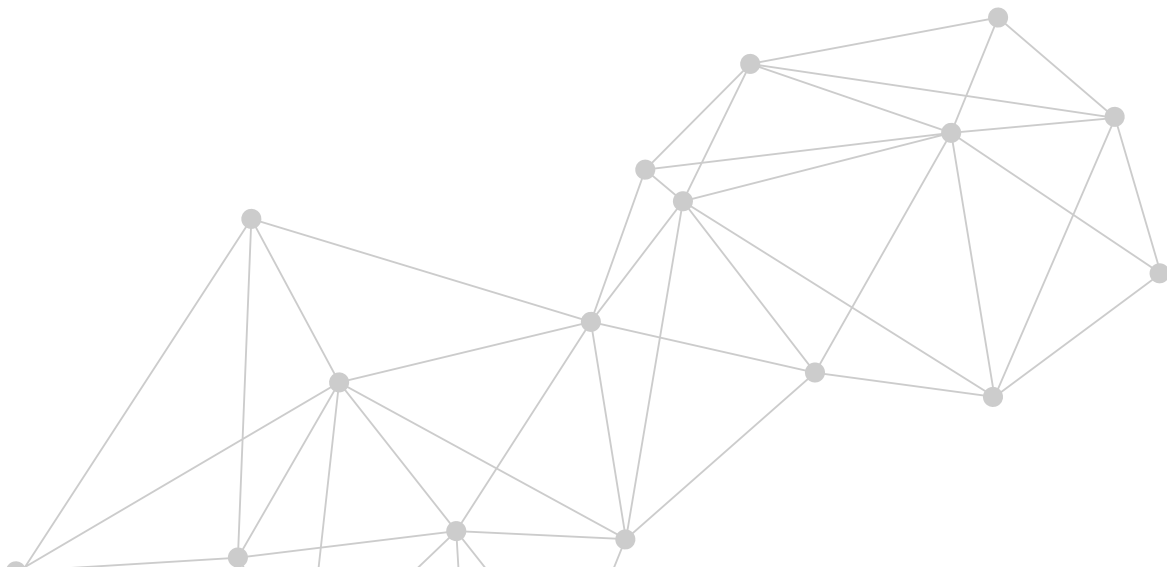
CRS4 offers high-performance computing support to the scientific community and industry through its constantly updated computing centre.

Recent investment includes:

* next generation computing cluster

* artificial intelligence systems with CPU/GPU accelerators

* nodes for computing, 3D graphics, Machine Learning and Big Data

* new performance storage system for data enhancement and security of the computing

HYBRID AND STANDARD HPC CLUSTER	**> 400 NODES FOR COMPUTING**	**LOW LATENCY NETWORK AND HIGH SPEED**
X86_64, Nvidia GPU, AMD GPU	**> 10000 CORES**	**STORAGE 5 PB**

NEXT
Next Generation Sequencing

CRS4 hosts one of the largest New Generation Sequencing (NGS) platforms in Italy.
The NGS Core Facility, connected to CRS4's computational resources, is part of an integrated infrastructure for the fully automated management of sequencing data.
Synergies between the sequencer and the computing power of the Centre allows CRS4 to carry out large-scale projects, from data production to scientific analysis.
Since its activation, the sequencing platform has been based on the use of Illumina technologies in various fields of application – including complete sequencing of genomes, exomes, target regions, transcriptomics and the identification of binding sites on DNA.

EXPERIMENT	ORGANIZE	ANALYZE
DNA Sequencing	DATA Repository	Genomics
RNA Sequencing	DATA Integration	Transcriptomics
Any NGS Applications	DATA Virtualization	Any data analysis workflow

UbiDP
Ubiquitous Digital Platform

UbiDP is CRS4's digital operating platform that can manage large amounts of data (images, sounds, videos) from different sources (public, sensors, internet, etc.) and transform them into images and graphics for the management and monitoring of events and critical situations, using specially developed software technologies. The platform is operational for the coordination of the territory logistics in case of possible emergencies, such as floods and fires and for the traffic and parking management, as well as for the control of people flow during big events.

EMERGENT STATES

TRAFFIC MANAGEMENT

LOGISTICAL TERRITORIES

**PEOPLE FLOW**
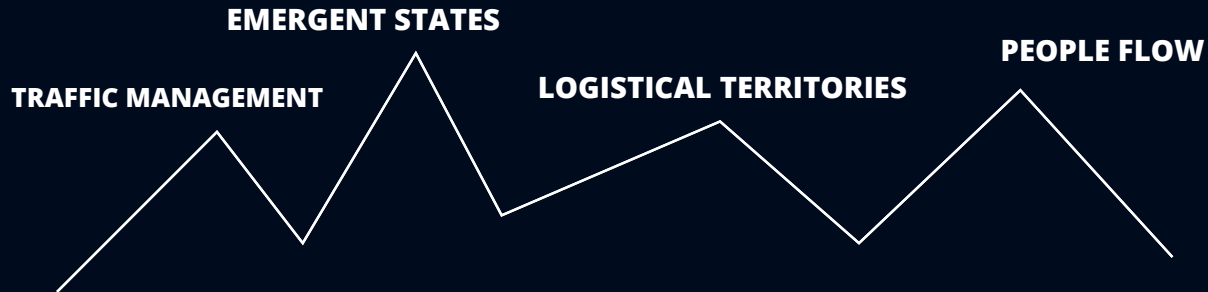
DIGITAL TECHNOLOGIES FOR AEROSPACE

Aerospace technologies for Earth observation (satellite and aerial recognition) enable significant scale economies for the implementation of territorial monitoring systems and decision support tools in active development policies. Innovative solutions are offered in a number of economically relevant areas of the ecosystem: environment, mobility and logistics, cultural heritage, tourism, agri-food. Technologies for space missions (artificial intelligence, robotic systems, autonomous navigation) area also an object of research – with the intention to initiate a technology transfer process towards the establishment of technology-intensive precision manufacturing development poles.

GEOGRAPHIC INFORMATION SYSTEMS

Here activity focuses on the application of Geographic Information Systems (GIS) technologies to a wide range of domains: urban planning, industry, environment, health, tourism and culture, and on the development of Decision Support Systems using georeferenced data. In addition, through the study and development of methods for processing and analysing satellite data for Earth Observation, the program is developing new remote sensing survey methodologies, applied to the fields of forest management, precision agriculture and cultural heritage.

SMART ENVIRONMENTS AND TECHNOLOGIES

This programme operates in the Smart environment and technologies area, while developing activities in connection with the local productive system, in terms of knowledge and technology transfer and sharing. Through the involvement of industrial, entrepreneurial and institutional actors, projects are carried out on Smart Cities mobility, logistics and environmental modelling. Activities cover the Internet of Things, WebGIS and environmental modelling, with applications in agriculture, cultural heritage and tourism. Aerospace research integrates knowledge and skills acquired in the field of digital technologies with those of aerospace, related, in particular, to satellites.
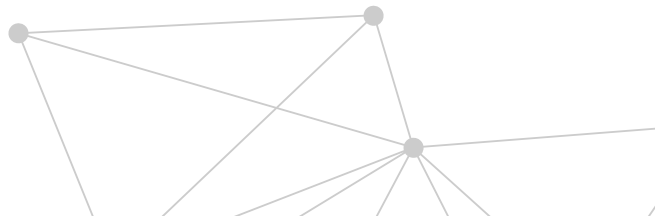
GAME-BASED INTERACTION AND TECHNOLOGIES

The research focus here is to investigate the topic of gaming in order to explore how technologies, methodologies and algorithms, directly taken from this field, can be profitably applied in other contexts. Topics include artificial intelligence, robotics and immersive interaction. Activities focus on innovative approaches and solutions in the following areas: rapid prototyping of interfaces and control devices; human-robot-environment interaction systems; design of new media communication tools based on technologies derived from the world of video-games (virtual/augmented/mixed reality); gaming and its derivations (gamification) – while also conducting research in other sectors (e.g. tourism, training, edutainment, marketing).

HPC FOR ENERGY AND ENVIRONMENT

The challenges involved in energy efficiency, renewable energy, geophysical exploration, sustainable land use and natural resources are of fundamental importance for industrial innovation, regional economies and social development. To meet these challenges, the Centre's high-performance computing (HPC) sector incorporates the contributions of science and technology in interdisciplinary solutions that benefit from mathematical modelling, HPC as well as information and communication technologies (ICT). The software thus developed provides a wide ranges of solutions including high quality applications and highly optimised services based on state-of-the-art infrastructures.

DIGITAL AGRICULTURE

The programme focuses on the adoption of digital data from remote or field sensors for the input into decision support tools, on the exploitation of high-performance numerical computing technologies for the development of large-scale machine learning models, and on the study of artificial intelligence techniques for service robotics in agriculture – based on the use of the latest hardware solutions for edge computing.

IMAGING AND NUMERICAL GEOPHYSICS

Here research is focused on the development of innovative mathematical models and numerical algorithms, combined with advanced software engineering techniques, for the implementation of high-performance industrial applications in the field of imaging sciences and geophysical natural resources prospecting. This team, whose skills cut across the disciplines of physics, mathematics, engineering and computer science, has achieved the long-term objective of CRS4: the transfer of knowledge, with financial returns, from scientific research to industry.

MODELING, SIMULATION AND DATA ANALYSIS

Here the program activity applies scientific techniques and methods towards the solution of biological, biotechnological, biomedical and pharmaceutical problems. Our multidisciplinary approach to these issues has its roots in physics, mathematics, chemistry and life sciences. Over the years, extensive skills have been developed in the modelling and simulating of cell growth and of proliferation processes, in molecular dynamics and structural properties of proteins as well as in the application of artificial intelligence techniques for the prediction of their material properties.

ENVIRONMENTAL SCIENCES

Here the research programme uses high-performance computing architectures to implement software based on complex numerical models to solve problems related to the management of environmental resources and then applies them to real case studies. Activities include the simulation and analysis of atmospheric statistics and the assessment of related meteorological and climatological risks, from regional to small scale, through the development of physical-statistical post-processing techniques.

SMART ENERGY SYSTEMS

Here the programme involves research applied to energy technologies for industry, services and their consumers. The activities contribute to regional, national and European objectives for the reduction of Greenhouse Gas emissions, in production technologies and energy conversion applied to the design of conventional and innovative plants with high environmental sustainability, and to artificial intelligence systems for distribution networks.

ICT - INFORMATION SOCIETY

This sector carries out R&D activities for innovative applications and technology transfer, in collaboration with universities, research centres and industry. The transversal competences of the sector cover wide fields of application, both in the professional and consumer sectors: tourism, transport, culture, territory, agri-food, teaching, natural and multisensory interaction, augmented reality, digital content and new media, artificial intelligence, deep learning for medical diagnostics, internet of things, semantic web and more generally the whole world of ICT and Information Society.
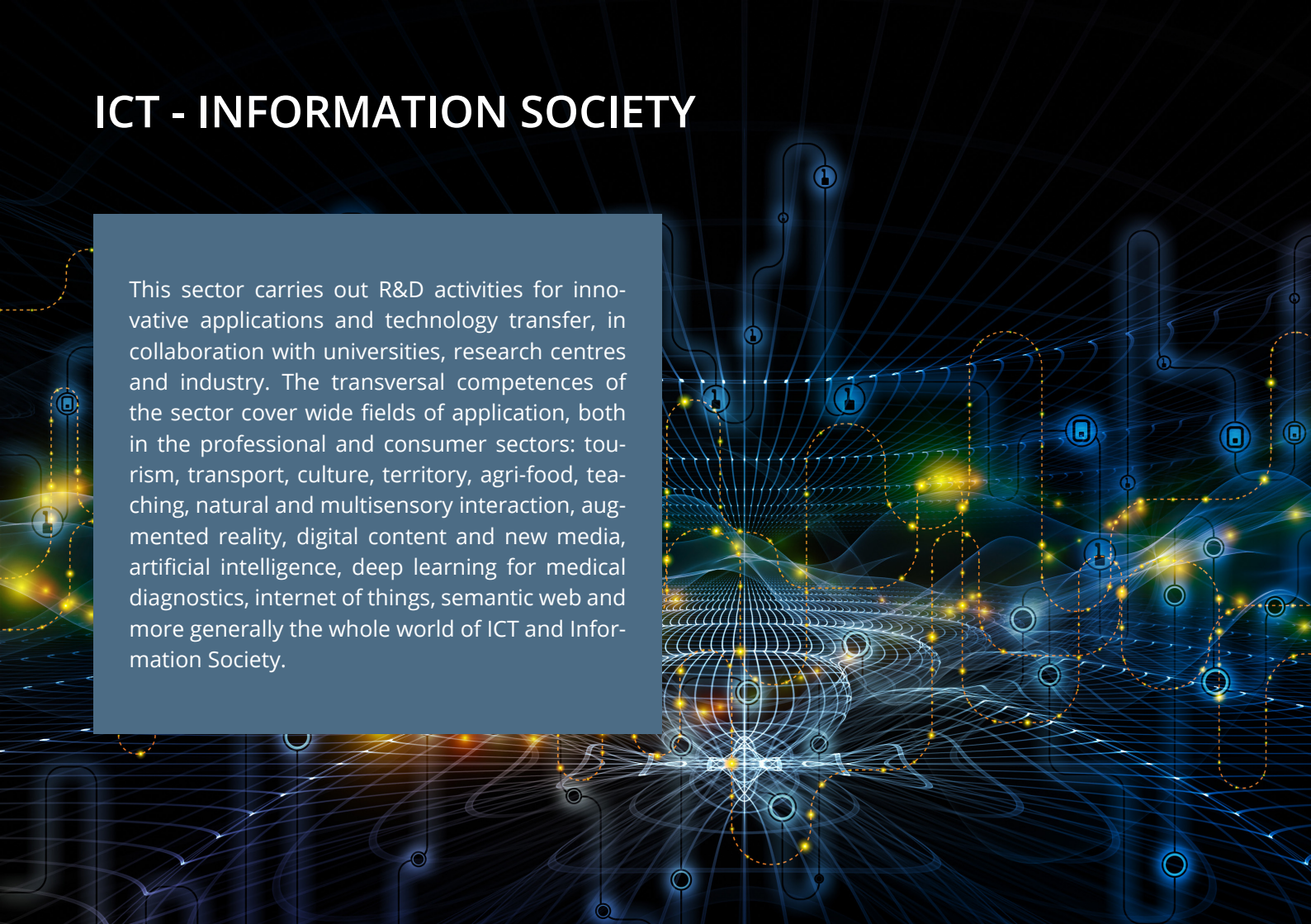
COLLABORATIVE AND SOCIAL ENVIRONMENTS

The programme investigates Human Computer Interaction and Interaction Design to improve the quality of computer-mediated human interactions. The focus is on user-centred interactive environments, including the development of new prototypes and industrial products, encompassing computer vision and data analysis algorithms, visualisation and multi-projection systems, augmented and virtual reality, immersive and modal, tangible, manipulative and gestural interfaces, interaction technologies, multi-sensorial systems and interactive surfaces. The research activities are applied in various fields (culture, tourism, communication, etc.) through research and industrial projects.

INTERNET OF THINGS AND ENERGY EFFICIENCY TECHNOLOGIES

Here the programme develops tools for accessing the services of public administration and private companies, adopting the opportunities offered by IOT technologies, artificial intelligence and vision, distributed computing architectures and energy monitoring and efficiency. In collaboration with regional bodies, the programme also promotes the social inclusion of people with disabilities through the use of IT tools and methods to improve the life quality. A further field of application concerns precision agriculture, the enhancement of agri-food supply chains as well as animal and plant welfare, with the testing of new organic agro-pharmaceuticals, essential oils and hydrolysates from mainly native officinal/medicinal plants.

CONTENT TECHNOLOGIES AND INFORMATION MANAGEMENT

This programme develops technological solutions for the audiovisual industry through the design and testing of algorithms and prototypes that acquire knowledge from audiovisual content. The projects cover: territorial monitoring (detection of the density and flow of people and vehicles by analysing aerial photographs in real time); medical diagnostics (classification of X-rays and ultrasound scans using artificial neural networks); business analytics (detection of customer habits and behaviour in the retail sector by the analysis of video footage). For these activities a scalable edge-computing platform (for the parallel analysis of video streams using deep learning techniques) and a Digital Asset Manager made extensible via artificial intelligence models are used.

EDUCATION TECHNOLOGIES

Here the programme activities focus on the study, development, adaptation and integration of innovative technologies and methodologies for education, training on demand and orientation. Pedagogical strategies are developed for teachers and trainers interested in the critical application of innovation, through the study of innovative environments and adaptation to precise areas of knowledge. Activities also include remote access to scientific and technical experiments for teaching using Artificial Intelligence.

VISUAL AND DATA INTENSIVE COMPUTING

This sector is dedicated to the research, development and application of innovative solutions for the acquisition, creation, processing, distribution and exploration of complex and massive datasets and real-world environments. Activities are focused on: general purpose enabling technologies for scalable computing and analysis (big data, data analytics, automation, machine learning, distributed computing); visual computing methods and systems (computer graphics, scientific and information visualisation, machine vision, image processing, innovative displays and user interfaces); specialised solutions for data acquisition, integration, sharing and analysis in industrial processes, healthcare and biomedical research (data modelling and management, interoperability, traceability and reproducibility, data provenance).

SCALABLE COMPUTING AND ANALYTICS

The focus of the activities here is to devise, develop and test innovative solutions in the field the scalability of the processes required for conveying, processing, analysing and managing large data streams. The theme is entered upon the study and application of state-of-the-art techniques for distributed computing, automation and machine learning which are then combined to increase the potential for collecting and using available data in reproducible ways. The group's work finds important application contexts in the fields of urban computing, bioinformatics and clinical informatics – thanks also to synergies and close collaborations with others industry groups and various other actors nationally and internationally – while retaining transversal applicability.

DIGITAL HEALTH

Through the research, development and testing of scalable models, tools and technologies, this programme is committed to improving the acquisition, sharing and analysis of complex and heterogeneous data generated by biomedical care and research processes. Activities include: modelling of data and processes using open and international formalisms; technical and semantic interoperability between clinical domains; creation of scalable systems for collaborative analysis and the reuse of available information, with a specific focus on traceability and reproducibility of each process step. The group collaborates with leading hospitals, research centres and companies specialised in the healthcare sector, and is working upon the definition of standards and guidelines for clinical informatics in the framework of the main international reference bodies (such as IHE, HL7, OME and openEHR).

VISUAL COMPUTING

The aim of this programme is to create new scalable technologies to acquire, create, distribute, explore and analyse complex objects and environments by integrating these technologies into interactive visual simulations and virtual environments. Research activities cover many aspects of visual computing and include topics such as computer graphics, scientific and information visualisation, computer vision, image processing, display and user interface design, human-computer interaction, geometric processing, and massive models.

ACQUISITION, PROCESSING AND VISUALISATION LAB

The aim here is to develop, apply and integrate sensors, computational resources and specialised instrumentation for CRS4's activities in the field of visual and data-intensive computing. The group interfaces with the facilities of the Centre, and manages hybrid CPU/GPU systems directly connected to interaction and visualization devices. Acquisition devices include camera arrays, 3D scanners, custom multi-light multi-spectral acquisition devices and environmental sensors. Visualisation tools range from high-resolution multi-touch systems to experimental light-field displays for interactive quasi-holography. Activities concern smart cities and cultural heritage, with large-scale acquisition campaigns and the development of large-scale interactive museum installations.