Description of the specialization

Specialisation covers problems of smart networks and information and communication technologies and geoinformation technologies, both as independent and interconnected elements. However, attention should be paid to the potential resulting from combination of both the scope of examinations and implementations.

The notion of “smart networks” means teleinformation technologies and systems[1] used in various infrastructures (e.g. energy, transportation, telecommunication, health, factories, houses, cities, vehicles), in order to provide, *inter alia*, optimisation of operation, savings of resources, including energy, environmental protection, ergonomics of use, advantages arising from mutual communication and information exchange. Smart networks and systems are characterized with the following features [2]: autonomous character, ability of self-organisation, adaptation and decision making, resistance to errors and faults, scalability, predictability of quality assurance, architectural openness, teleinformation safety.

Information and communication technologies (ITC), interchangeably referred to as information and telecommunication technologies or information technologies, are a family of technologies that process, collect and send information in electronic form [3].

The notion of “geoinformation technologies” covers technologies related to acquisition, storage, processing, analysing, providing access to and visualisation of geoinformation, i.e. information, for which location is specified in an agreed reference system, and defines, reads out and visualises relationships between the objects and phenomena occurring in that space. First of all, geoinformation is related to geographical (earth) space, but geoinformation technologies can be also applied for modelling of other spaces. Geoinformation technologies usually use information and communication technologies, in particular geo-ITC and teleinformation solutions and methods. “Geoinformation technologies” fall into the field of research called geomatics, and are especially related to the discipline of “land surveying and cartography”.

[1] Teleinformation system – a set of cooperating IT devices and software, ensuring processing and storage, as well as sending and receiving data through telecommunication networks using ta final device relevant for a given type of network (definition as stipulated in the Act of 16 July 2004 – Telecommunications Act).

[2] R&D works should cover one or more of the listed features.

[3] Based on the definition in: “Społeczeństwo informacyjne w Polsce. Wyniki badań statystycznych z lat 2006-2019”, Informacje i opracowania statystyczne, GUS, 2010

I. TECHNOLOGIES OF THE INTERNET OF FUTURE, TECHNOLOGIES OF THE INTERNET OF THINGS, EMBEDDED SYSTEMS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following extent:

1. Smart network components
2. Solutions enabling development of services for a new generation network (*inter alia* 5G)
3. Infrastructure for prototyping, testing and experiments, serving for implementations
4. Optical, wireless network technologies
5. Solutions of the Internet of Things
6. Semantic Web components, Linked Data
7. Wearable devices

II. SMART NETWORKS IN INFRASTRUCTURES

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, in the following infrastructures:

1. Smart cities
2. Smart homes and buildings
3. Smart factories and enterprises
4. Intelligent Transportation systems
5. Smart vehicles
6. Smart transmission networks, such as electrical, heat, fuel, water, sewage, communication, telecommunication network (including smart networks management systems)

III. ARCHITECTURES, SYSTEMS AND APPLICATIONS IN SMART NETWORKS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following

extent:

1. Integration of smart systems
2. Communication in critical situations
3. Optimisation of the use of communication network resources
4. Preserving communication continuity
5. Ensuring communication availability
6. Self-organising communication networks
7. Smart services for residents, *inter alia* health and education (smart healthcare, smart education), support for persons with disabilities
8. Simulators and “serious games” solutions
9. Supporting decisions
10. Managing the degree of load and energy consumption in data centres

IV. INFORMATION MANAGEMENT IN SMART NETWORKS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following extent:

1. Analysis of data collected in clouds
2. Optimisation of effectiveness and pace of Cloud Computing
3. Dispersed systems and parallel processing
4. Machine learning
5. Artificial intelligence
6. Virtualisation
7. Processing of complex, large, changeable and diversified data collections (big data, data mining)
8. Compression and reduction of data sizes
9. Effective verification, archiving and storage of data
10. Knowledge management in organisations
11. Utilisation of social networks in data acquisition and analysis as well as information distribution
12. Video content analysis for automatic detection of objects and events, optimisation of visual information analysis
13. Hardware infrastructure and software enabling foundation of network systems and applications of large-scale data

V. HUMAN-MACHINE AND MACHINE-MACHINE INTERFACES IN SMART NETWORKS

Development of innovative products, technologies, processes (or significant improvement of the existing ones), in the area of smart networks, to the following

extent:

1. Smart machine-machine interfaces
2. Smart human-machine interfaces (HMI), in particular:

- Biometric systems and solutions
- Recognition of emotions, behaviours and gestures
- Augmented reality
- Imaging and visual information analyses, adapting to available communication and visual resources
- Acoustic and voice communication

VI. STANDARDISATION, SAFETY AND MODELLING OF SMART NETWORKS

Development of innovative (new or improved) cross-cutting solutions for establishment and development of smart networks

1. Teleinformation security in smart networks and systems
2. Cyber security
3. Privacy protection
4. Smart security systems
5. Support for development of methodologies, standardisation processes and their implementation
6. Methods for modelling and automatic testing (software development quality improvement – creating applications)
7. Utilisation of geoinformation in development of smart networks and systems

VII. POSITIONING AND NAVIGATION

Development of innovative products, technologies, processes, methods (or significant improvement of the existing ones) intended for determination of an object’s position in defined space, its navigation or monitoring
(with the necessary level of security), in the following scope:

1. Improvement of quality of satellite and other spatial positioning systems (in particular their accuracy and integrity).
2. Multimodal determination of objects' positions.
3. Internal location systems.
4. Navigation and location applications using information from many sources in real time.
5. Navigation and location applications with innovative methods of information transmission (including cartographic), in particular with innovative imaging methods.

6. Network centric navigation systems.
7. Remote monitoring of moving objects.
8. GNSS systems protection against intentional and unintentional interferences, and safe GNSS systems for authorised users.
9. Development of components for positioning and navigation systems (*inter alia* for satellite navigation) for ground and on-board segments, including embedded software.
10. Utilisation of smart networks in development of location and navigation systems.

VIII. OBTAINING GEOINFORMATION

Development of innovative products, technologies, processes and methods (or significant improvement of the existing ones) for obtaining spatial information, to the following extent:

1. Non-invasive measurement systems (e.g. remote sensing and aerial, satellite and short-range photogrammetry, aerial and terrestial laser scanning, ground-penetrating radars, radar observations, hiperspectral observations, thermovision).
2. Solutions in teledetection, photogrammetry and other fields allowing automated identification of objects and their features, as well as changes in spaces, on the basis of signal, data and imaging analysis.
3. Mobile data acquisition (including mapping) and mobile GIS systems.
4. Instruments, sensors, systems for obtaining and displaying spatial data or new ways to integrate instruments, sensors and systems (including manned and unmanned mobile platforms).
5. Land surveying control and control-measurement systems.
6. Utilisation of smart networks in geoinformation acquisition systems.

IX. PROCESSING, ANALYSING, PUBLISHING AND VISUALISING GEOINFORMATION

Development of innovative products, technologies, processes and methods (or significant improvement of the existing ones), for processing, analysing, storing, publishing and cartographic visualisation of spatial information, in the following scope:

1. Development of spatial knowledge bases.
2. Utilisation of computational intelligence and semantic webs for geobusiness intelligence.
3. Spatial data mining.
4. Spatial data harmonisation.
5. Fusions of various spatial data and automation of geoinformation processing.
6. Solutions for effective geoinformation exchange in environments exploited by numerous users, including those exploited in real time.

7. Modelling (including cartographic), preparation of scenarios and prognoses for changes in space.
8. Monitoring changes in space (e.g. based on Copernicus data, based on data from laser scanning) and resulting spatial data update.
9. Cartographic data visualisation, e.g. visualisations of spatial data using Augmented Reality techniques, holography, contextual visualisations, visualisations taking into account the time aspect, infographics, 2D/3D visualisations.
10. Utilisation of solutions in the field of smart networks in the processing, analysis and publishing of geoinformation.

X. GEOINFORMATICS

Development of innovative systems, applications, algorithms, functions, models, standards (or significant improvement of the existing ones), with utilisation of modern ICT techniques, in order to guarantee effective acquisition, storage, processing, analysing, publishing, visualisation of spatial information, in the following scope:

1. Models and structures of spatial data, standards and forms of recording, compressing and exchanging data.
2. Spatial cloud computing.
3. Hardware infrastructure and software for effective processing of large-scale data.
4. Spatial big data management.
5. Spatial data harmonisation.
6. Effective filtration, aggregation and generalisation of spatial information.
7. Ensuring the security of spatial data resources.
8. Geoinformation real-time applications, and those taking into account the time dimension (e.g. multitemporal).
9. Optimisation of moving objects routing.
10. Integration of geoinformation systems with other IT systems, e.g. ERP, CRM, SCADA, BIM[1].
11. Automation of the process of integration of state registers with spatial databases.

[1] ERP – enterprise resource planning, CRM – customer relationship management, SCADA – supervisory control and data acquisition, BIM – building information modeling

XI. INNOVATIVE APPLICATIONS OF GEOINFORMATION

Development of innovative products, technologies, processes, methods (in particular

in connection with technologies of smart networks), which will significantly improve already existing or create new ways of using geoinformation technologies in:

1. Smart cities systems.
2. Intelligent Transportation Systems, logistics, transport and forwarding, and vehicle control.
3. National security systems, public security systems, forensics, crisis management, rescue services, health care.
4. Navigation and land, sea and air safety systems.
5. Smart management systems for transmission networks.
6. Vehicle simulators, simulators of situations and phenomena (e.g. flight simulators and simulators for crew training, tactical simulators and "serious games" solutions).
7. Advanced planning systems, spatial economy, real estate management, systems for social geoparticipation supporting spatial management.
8. Advanced systems for livestock and crops production (e.g. precision agriculture, smart forestry).
9. Advanced systems used in geomarketing.
10. Advanced information systems supporting the implementation of EU directives, the implementation of which requires geoinformation.
11. Advanced systems used in the study of the Earth (e.g. in geology, geophysics, archeology, mining).
12. Systems for environmental monitoring and assessment, and systems aimed at preventing the effects of climate variability and extreme hydrometeorological phenomena.
13. Systems for identification and optimisation of natural resources exploitations, and systems intended for counteracting the negative effects of human activity (engineering, industrial, economic) and minimise the effects of such activity.