Internship topics

India – Bulgaria

2023

1. Faculty of telecommunications

The Faculty of Telecommunications is the leading educational institution in the field of communication technologies in Bulgaria. It offers advanced Bachelor, Master and PhD Degrees training in "Telecommunications". Telecommunications is one of the most modern and dynamic areas of engineering and technology nowadays. Area, where a huge investmentis allocated and many leading companies in the world are working, with the lowest unemployment and a constant need for qualified specialists.

Proposed Topics:

Object Shape Evaluation and Dimensions Estimation from Images

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

Industrial applications relating to manufacturing of large number of details rely on precise estimation of their dimensions and overall shape evaluation in order to comply with common standards and to ensure high reliability of the final products. Non-automated measuring of dimensions is proved to be slow and expensive. Digital imaging offers a way with the use of data processing algorithms to automate the whole process at low price rendering it extremely efficient. In this project various operators applied over digital images of different objects in size and shape will be investigated, e.g. edge and corner detectors, morphology operators, segmentation functions and others. Sequence of processing steps need to be selected for a given type of objects captured at different positions over non-stationary background in orderto complete the measurements. Based on them, final decision should be made about the compliance of the manufactured object. Testing with different real-world images will provide wider capabilities for the students to use freely and in a flexible manner the most popular techniques in the field. It is recommended, although not obligatory, the prior knowledge of at least one programming language, some experience in signal (image) processing and good knowledge in math (undergraduate level, engineering oriented). The working environment for testing is Matlab.

Methods and algorithms for automatic 3D object model construction from multiple views

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

Objects which occupy space in the virtual environment can be entities that the user can observe and/or manipulate. So creating consistent and useful models of objects and background of the constrained space is essential. This task explains how to apply mathematical transforms that translate them in the virtual world. This involves two components: Translation (changing position) and rotation (changing orientation). The main goal of this task is to find the best ways to express and manipulate 3D rotations, which are the

most complicated part of moving models. Accurate models of already existing complex shaped objects are required for synthesizing arbitrary views and also for recognizing them. Automatic construction of geometric models of 3D objects involves three major steps: (i) dataacquisition, (ii) registration of different views, and (iii) integration. Data acquisition involves obtaining either intensity or depth data of an object from multiple viewpoints. Accurate 3D spatial relations between different views may not be easily and directly obtained in many cases. Therefore, integration of data from multiple views is not only dependent on the representation chosen for the model description, but also requires a knowledge of the transformations relating the data obtained from multiple views. The goal of registration, is to find the transformations that relate multiple views, thus bringing the object regions that are shared between them into alignment. Integration merges data from multiple views using the computed view transformations, to create a single surface representation in a unique coordinate frame.

Methods and algorithms for skeleton generation and tracking of skeleton joints for human activity recognition

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

The 3D avatar generates large amount of data points, which have to be sent through the network in real-time. To create the skeleton, a human body is described by a number of joints representing key body parts such as head, neck, shoulders, elbows, wrist, torso, hip, knee and ankles. Each joint is represented by its 3D coordinates. The tracking involves determining all coordinates of these joints in real time to allow fluent interactivity. Multiple sensors are necessary to avoid self-occlusion, which is a common problem among most vision-based sensing systems. However combining the measurements from the different sensors creates a new issue known as the data fusion problem. Based on the captured skeletal data an avatar can be animated. The created 3D model needs to be rigged with the captured skeleton hierarchy and appropriate texture maps. A skeleton based animation strategy must is employed for robustly and accurately fitting the avatar to the skeleton and then large scale deformations and movements can are applied in real-time.

Real-time facial identification, facial features detection and tracking in multi-view environment

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

We will develop and implement methods and algorithms to efficiently identify human faces, including: improved method with increased accuracy for face segmentation; method and algorithm for extracting facial features, after transformation into subspaces for dimensionality reduction and a classifier based on a deep learning neural networks. The method for face segmentation of individuals will be based on sequential combination of the known method of Viola-Jones and convolutional neural network CNN. The developed algorithm will serve to recognize expressions based on facial characteristics. Software development and simulation algorithm to extract facial features will be based on reducing the dimensionality of data by face segmentation in the wavelet space and principal component analysis (PCA). The

classification will be made by classifiers such as convolutional neural networks or other types of deep learning neural networks suitable for this application.

Real-time photorealistic animation of the avatar's body and head movement

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

The main idea of the project is to combine geometry and texture based techniques to animate a personalized avatar. The user's performance is captured by an RGB-D camera and transferred to the avatar in real-time. We rely on a skeleton based animation to transfer large scale deformations of the body, e.g. walking, jumping or moving the arms. Each joint of the skeleton is represented by its 3D coordinates. The tracking involves determining all coordinates of these joints in real time to allow fluent interactivity. Multiple sensors are necessary to avoid self-occlusion, which is a common problem among most vision-based sensing systems. However combining the measurements from the different sensors creates a new issue known as the data fusion problem so the sensors can work together to correct any inaccurately captured joint data. Based on the captured skeletal data an avatar can be animated. The created 3D model needs to be rigged with the captured skeleton hierarchy and appropriate texture maps. A skeleton based animation strategy will be employed for robustly and accurately fitting the avatar to the skeleton and then large scale deformations and movements will applied in real-time.

Designing and simulating realistic clothing

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

Dressing virtual avatars and animating them with high quality, visually plausible, results is a challenging task. Highly realistic physical simulation of clothing on human bodies in motion is complex: clothing models are laborious to construct, patterns must be graded so that they can be sized to different characters, and the physical parameters of the cloth must be known. Current methods for 3D garment capture are not sufficiently accurate or detailed to compete with physical simulation. Existing capture methods suffer from low resolution, static shapes, simple body motions, capture only one clothing piece, or do not segment the clothing from thebody. The main goal of this task is to develop a data-driven clothing capture approach; to capture dynamic clothing on humans from multi-view scans and transform it to more easily dress the virtual avatars. The first step will be capturing the garment geometry in motion on a body, estimate the body shape and pose under clothing, and segment and extract the clothing pieces. Then the captured clothing can be transferred to new body shapes and poses.

Create a 3d model of real object

Supervisor: Assist. Prof. Dr. Nicole Christoff, E-mail: nicole.christoff@tu-sofia.bg

The aim of this project is to create a parametric modeling of objects and to create a photorealistic avatar. To achieve this, a 3D scanner and / or RGB-D sensors will be used to acquire the necessary data to be processed (point cloud). Before the object size can be calculated, the point cloud must be filtered to segment the object from the surrounding

environment. This should be done using an automatic segmentation techniques. After the correct segmentation of the object, an algorithm has to be developed and applied to animate this object.
The deliverable is a report including:
 state-of-the-art on various approaches for modelling of an object;
 improved algorithm for object modelling and selection in 3D space;
 created a database of deformable object models;
 results from simulation experiments related to the developed algorithms.
Programming language: C ++ / Java / Matlab
Tools at disposition: 3D scanner Sense and test field table

Scan and avatar yourself

Supervisor: Assist. Prof. Dr. Nicole Christoff, E-mail: nicole.christoff@tu-sofia.bg

The objective of building human representations is to extract compact, features to encode and characterize a human's attributes from human shape, pose, and motion, when developing human-centered reasoning systems. Skeleton-based human representations are attractive, due to their robustness to variations of viewpoint, human body scale and motion speed as well as the real-time, online performance. 3D skeleton-based representations are able to model the relationship of human joints and encode the whole body configuration. They are also robust to scale and illumination changes, and can be invariant to camera view as well as human body rotation and motion speed. In addition, many skeleton-based representations can be computed at a high frame rate, which can significantly facilitate online, real-time applications.
The deliverable is a report including:
 state-of-the-art on various approaches for modelling of human body;
 improved algorithms for human body modelling with real-time application in 3D space taking into account changes in the multi-view environment;
 created a database of deformable human body models;
 results from simulation experiments related to the developed algorithms.
Programming language: C ++ / Java / Matlab
Tool at disposal: 3D scanner or Kinect

Next Generation Wireless Communications (NGWC)

Supervisor: Assoc. Prof. Dr. Agata Manolova, E-mail: amanolova@tu-sofia.bg

The next-generation network infrastructures like 5G and 6G are expected to be dynamic and sophisticated, while at the same time enabling many technological concepts like the Internet of Things, Smart Cities, Self-Driving Vehicles, etc. The implementation of those concepts implies the need for networks with higher capacity, higher bandwidth, lower latency, as well as better user integration and greater coverage. Developing solutions to all those requirements necessitates the joint commitment of a multidisciplinary research group. We aim to contribute to this worldwide effort by leveraging our expertise in the field and utilizing our communication research facilities. The students working in this subject will take part in projects focused on embedding artificial intelligence into NGWC, exploring intrinsic network heterogeneity, building sustainable network infrastructures, etc. The students will gain experience in Machine Learning Applications for Radio Signal Processing, Resource Allocation Techniques, Spectrum Monitoring, IoT, LoRa, Radio Access Networks, Software Radio, Cognitive Radio, mMIMO etc.

2. Faculty of Industrial Technology -

The Faculty of Industrial Technology (FIT) at the Technical University of Sofia trains engineers in the professional field of Mechanical Engineering and Technologies. FIT educates students in BSc and MSc specialties in professional "Machine Engineering".
The faculty offers the following undergraduate programs:
Machine-Building Technology and machinery (MTM);
Industrial Technology (IT);
Computer Aided Design and Technology in Machine-Building (CADTM);
Advanced Industrial Technologies (in English) (BAIT).
The degree MSc is provided in two programs:
Machine-Building Technology and Machinery (MTM) with four differ programs:
Materials Science and Technology;
Welding;
Design of technology and engineering equipment;
Innovation and maintenance of manufacturing.
Computer Aided Design and Technology in Machine-Building (CADTM).

The students will work in the the faculty's CAD/CAM/CAE IN INDUSTRY laboratory. Here in the field of CAD / CAM / CAE technologies are 12 engineers with huge industrial experience. The laboratory provides training for students, trainees, graduates, postgraduates and PhD students. The main directions of activity of the laboratory are:

- Conceptual design;
- Preparation of 3D models and design documentation;
- Structural analysis and optimization;
- Kinematic and dynamic analysis;
- Development of PDM software;
- Rapid prototyping and forming tools.

Supervisor: Assoc. Prof. Dr. Yavor Sofronov, E-mail: ysofronov@tu-sofia.bg

Internship subjects offered:

1. **New methods and technologies used for virtual validation of mechatronic systems**
2. **Development of new methods and technologies for virtual and physical design of lattice structures for personalized implants**
3. **Research and development of methods and technologies for evaluation and 3D digitalization of virtual factories**

3. Faculty of Electronic Engineering and Technologies

Faculty of Electronic Engineering and Technologies (FEET) is recognized as a leader in education and research in the field of electronics at national level (accreditation by Institution of Electrical Engineering, London, UK). Training in FEET is consistent with the latest advances in electronics, as well as with educational and research programs of leading European universities in England, Germany, France, The Netherlands, Italy, etc.

Supervisor: Assoc. Prof. Dr. Elitsa Gieva, E-mail: gieva@tu-sofia.bg

Laboratory "Optical Mechatronic Technologies" - Section "Laser Technologies"

The main activities of the students will aggregate towards research in:

- The interactions of laser radiation with various materials - metals, dielectrics, semiconductors and biological tissues - are studied. The influence of processing modes and laser parameters on the final result of the processes, etc. will be investigated.
- Experimental and theoretical study of the surface interactions of radiation with substances and the change of the morphology of the surfaces, as well as their adhesion, tribological and optical properties.
- Experimental and theoretical study of laser ablation of various substances and its dependence on laser parameters (pulse duration and wavelength) and processing modes.
- Development of technologies for monochrome and color marking of various materials by laser annealing, laser ablation or laser bonding of materials.
- Development of technologies for precise laser microcutting of materials.
- Development of technologies for laser microwelding of heterogeneous materials.
- Precise optical measurements of the experimental samples.
- Computer modeling and optimization of physical processes with a view to obtaining one or another end result.