PhD Program in Sciences & Technologies for Electronics & Telecommunication

YEAR 2018

Curriculum in

Computer Vision, Pattern Recognition and Machine Learning

Visione Computazionale, Riconoscimento e Apprendimento Automatico

ATTENTION

The PhD application also implies to submit a research proposal under one or more themes chosen among those below indicated.
To write a proper research proposal, please follow the instructions indicated in the following file: https://pavisdata.iit.it/data/phd/ResearchProjectTemplate_2018.pdf

Research themes

Theme A
Computer vision for behavioral analysis and activity recognition
Tutor: Vittorio Murino

Study and development of techniques and systems for the analysis of behaviours, actions, expressions/emotions, and social signals in general, referred to both single persons and groups. In this context, methods for tracking, recognition, and classification of persons and objects starting from images and/or sequences acquired from cameras distributed in the environment in several sparse locations, and from other types of sensors (e.g., microphones) will be considered. The main goal is to exploit hints and findings coming from social sciences to capture and model human behaviour. Computer vision and machine learning constitute the focus of this research, and particular attention will be specifically devoted to deep learning models.

Theme B
Computer vision for the prediction of human intentions and activities
Tutor: Vittorio Murino

We want to go further the analysis of human movements and explicit behaviours to design methods and algorithms for the prediction of human intentions. Experiments are already running consisting in performing

simple human-object interactions with a goal which is not explicitly stated nor viewed, and the task is to classify the actual intention subsuming that action from 2D and 3D data. We also plan to carry out other visual experiments considering more complex human interactions involving many subjects, while predicting the final outcome of the observed interplay. Computer vision and machine learning, and more specifically convolutional neural networks (CNN) and Long-Short Term Memory (LSTM) networks, will be most investigated models.

Theme C
Human body modeling for Socially-Aware Computer Vision
Tutors: Vittorio Murino, Alessio Del Bue

To recognize and interpret human nonverbal behavior it is fundamental to try to identify the subjects involved, especially in the wild, that is, in real situations. To this end, part-based human body modeling is a mandatory task aimed at extracting from images the different components of the human body, like head, torso, arms, legs, etc., so as to estimate posture, gesture and gaze, all social cues widely known as useful hints to classify behavior and recognize situations. Further, real time tracking of body parts is equally important to increase such recognition performances, possibly adding prediction functionalities to these algorithms. Computer vision and machine learning constitute the focus of this research, and particular attention will be specifically devoted to deep learning models. Applications in the contest of surveillance and security as well as in the biomedical field (e.g., monitoring of elderly people) are envisioned.

Theme D
Crowd behavioral analysis and event recognition
Tutor: Vittorio Murino

Study and development of techniques and systems for the analysis of behaviours, events, social signals in general, referred to a large mass of people (crowd). The analysis and modelling of behaviour of groups and crowd seen as single entities will be considered. There is evidence that large groups of people and crowd are characterised by a collective behaviour that may emerge in different situations and can lead to interesting outcome from the point of view of the surveillance applications, and may help to detect and predict coming events. Machine learning as well as computer vision constitute the focus of this research, starting from early work in human body modelling/tracking to novel social force models able to grasp the complex dynamics of the human flow. Particular attention will also be specifically devoted to deep learning models.

Theme E
Re-identification
Tutor: Vittorio Murino

Study and development of biometric techniques for scene analysis and understanding. The research will mainly focus on person characterization, with possible focus on the usage of soft biometrics cues (3D, attributes) and in challenging conditions (e.g., crowd). The idea is to recover the identity of persons as viewed in different times and places, also considering face/body attributes, the so-called re-identification problem. Not only optical cameras will be used, but other information derived from different sensors may also be utilized (e.g., range). Moreover, the use of a pan-tilt-zoom (PTZ) camera able to identify specific features of a single person or groups, or addressing non-cooperative face recognition at distance, could be subjects of investigation. The robustness to environmental (real) conditions and the non-cooperation of the subjects are the main features to which the developed techniques will have to cope with to deploy this technology in real scenarios. Computer vision and machine learning constitute the focus of this research, and particular attention will also be specifically devoted to deep learning models.

Theme F
Multi-modal scene understanding
Tutor: Vittorio Murino

This topic is related to the research and implementation of algorithms that leverage the big data information, often multimodal, coming from 24h/7d video streams in order to monitor a certain environment and understanding in general what's going on there. In particular, we primarily aim at exploiting optical (RGB), 3D and acoustic data (also using our in-house opto-acoustical sensor, DualCam) to detect persons and objects, tracking and classify objects, events and behaviors in general. Due to the peculiar characteristics of deep learning architectures to cope with multi-modal data, we first target such class of methods to deal with this challenge, but other machine learning approaches will also be investigated.

Theme G
Biomedical imaging
Tutors: Diego Sona, Vittorio Murino

The wide adoption of biomedical sensors (e.g., MRI, TAC, SPECT, MEG, EEG, EMG, Fluorescence Microscopy, etc.) in various medical and biological investigations is fostering an increasing interest in advanced tools supporting the expert in the analysis and interpretation of the produced 2D/3D images and timeseries, both in clinical and scientific applications.
In this perspective, this theme will address the research related to the development of computer aided diagnosis (CAD) systems, with tasks ranging from image processing, image segmentation and object detection, up to automatic determination of diseases' biomarkers and more advanced data analysis. Particular attention will be devoted to structural data, functional data and the investigation of relationships between function and the underlying structure. To this aim multi-modal data analysis and fusion will play a strategic role. The development of such CAD tools will also require the design of novel computer vision, pattern recognition and machine learning techniques for biomedical data. In this line, particular attention will be given to deep learning models. Research will address a range of possible applications with particular attention to problems related to brain imaging (e.g., characterization of mental or neuro-degenerative diseases, investigation of cognitive functions, functional and structural connectomics, etc.) and cell imaging (e.g., cells detections and segmentation, relationship between cell morphology and function).

Theme H
Animal behavior analysis
Tutors: Diego Sona, Vittorio Murino

Behavioural neuroscience is a fundamental research field studying the biological bases of behavior providing insights into the mechanisms of the nervous systems producing anomalous behavior, and experimental subjects mostly involve animals. We are, therefore, involved in a multidisciplinary research activity, which need the development of techniques and systems for the automatic analysis of actions, postures and social behaviours of mice in home cages. In this framework, we aim at designing methods for tracking 24/7 the mice and objects from video recorded from multiple camera with different orientations. Computer vision and machine learning constitute the focus of this research, with particular interest in methodologies exploiting the spatio-temporal information. To date, we already have developed a series of algorithms based on Restricted Boltzmann Machines, but the investigation of other deep learning models is envisioned.