Title: Geometric Deep Learning for Action Recognition in Camera Networks for industrial applications

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Thanks to their advantages, high efficiency and big data streams, camera networks have been widely used in industry. Large-scale video networks not only contribute to intrusion detection, but also could contribute to enhance production performance and quality control in high demanding industrial applications. In this PhD thesis, the objective is to design advanced deep learning techniques on non-Euclidean spaces such as Riemannian spaces modeling the temporal evolution of human actions and interaction with industrial processes. We aim to focus on two different functionalities of a camera vision network-based system:

1. Collaborative detection and recognition of actions based on recent advances in geometric deep learning.

2. Automatic detection of abnormal situations based on video streams from connected cameras to control product quality.

The machine learning techniques will be adapted to Riemannian manifold to detect any abnormality in a given human behavior during the industrial processing chain. To the best of our knowledge, only one paper has already proposed an adaptation of convolution to Riemannian geometry. The intersection of Riemannian geometry and deep learning is completely new axis of research and the quantification of abnormal human behavior is also a new application, thus a new benchmark will be collected and shared with the scientific community.

The work will be done in collaboration with a local team of PhD students, Postdoc researchers and a start-up company working in smart video-surveillance.

I. Tasks description

I.1 Collaborative image processing in camera networks

One of the objectives of a vision network is to detect and recognize actions in an environment under surveillance. Visual processing usually consists of two steps: the first step is representing the video frames in the form of feature descriptors; while the second step is inferring the best decision matching with the reference model, in the current frame. However, it is challenging to prove whether an action is taking place or not. This can be simply explained by the unstable appearance of the scene through time. Typically, the non-rigid object model (size, shape, color, etc.), the irregular movements and the frequent occlusions require more robustness of the action recognition. Also, the unstable model makes hard the re-finding of the human target in different non-overlapping camera views.

Without complex pre-calibration in camera networks, we aim, in this thesis to design a collaborative visual detection framework based on combining graph signal processing and Geometric Bayesian filtering. Taking into account the bandwidth constraints, while ensuring a robust decision making, is one of challenging aspects in designing in-network video processing algorithms and robust multi-view visual descriptors for product quality control [5].

I.2 Video stream-based abnormal detection

After spatio-temporal detection of an action in a video stream, the objective of this part is to evaluate the abnormality and the danger of the occurring actions. In this project, we aim at making this decision automatically taken by the smart camera. The abnormal behavior is defined as the deviation from a normal behavior assumed to occur during a certain period. In other words, the camera considers a predefined period as describing the normal behavior of the scene such as a line of production. This database could be improved by integrating some situations considered to represent some dangerous abnormal situations. The objective of the on-line implemented algorithm is to efficiently and timely detect any abnormal situation.

Methodology

To approach the above-mentioned issues, the project aims to train the abnormal behaviors with their different levels. First, the temporal evolution of the resulting features will be modeled as trajectories in differential manifold and Riemannian geometry tools will be investigated for classification. Grounding on this precise space time representation, one can first develop a mathematical framework with various tools as (rate invariant) metrics, geodesics, derivatives and some statistics (means) on the underlying spaces. The machine learning will be adapted to Riemannian manifold to train the quantity of abnormality in a given human behavior and interaction with industrial production process.

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