Deep Learning for Multispectral, Multiresolution and Multisensor Data Fusion

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The Second International Workshop on Application of Multi-Sensor Fusion Technology for Autonomous Driving

1 Introduction

Sensor fusion technology is widely used in many real-world applications such as autonomous systems, pose estimation, video surveillance and remote sensing. The objective of this technology is to combine the data provided by the multiple sensors to achieve complementary information about the scene. Deep Learning (DL) has been successfully applied to a wide range of sensor fusion tasks showing state-of-the-art performance. The main reason is DL has a great potential in processing the multi-sensory data, which usually contains rich information in the raw data and is sensitive to training time as well as model size. However, the multisensor fusion approaches suffer from two challenges, which are (1) the feature extraction from various types of sensory data and (2) the selection of a suitable fusion level.

In this tutorial, we will introduce the trend of DL-based fusion architectures: early, late and middle fusion. We will discuss how they are employed for different computer vision tasks: classification, detection and segmentation. We will talk about advantages and disadvantages of these architectures. The talk covers methods and principles behind these architectures in two popular case studies: autonomous ships and remote sensing. Finally, we will illustrate this taxonomy through relevant examples from the literature and will highlight existing open challenges and research directions that might inspire attendees to embark in the fascinating and promising area of DL-based fusion methods. Attendees to this tutorial will leave with a good sense of how deep learning can be used for multispectral, multiresolution and multisensor data fusion.

2 Tutorial outline

This tutorial is of half-day duration (4 lecture hours). The outline of the tutorial include:

- Overview of well-known DL techniques for sensor fusion which can be classified into three nonexclusive categories: (i) data association, (ii) state estimation, and (iii) decision fusion. (40 min)

- A general introduction about modern sensors such as camera, radar, LiDAR and etc, and their advantage and disadvantage (30 min)
- Overview of the recent advances in DL-based fusion architectures: early, middle and late fusion for three main computer vision tasks (50 min)
- Applications (120 min): we will describe our research outcomes about DL-based sensor fusion methods in following applications:
  - Autonomous vehicles
  - Remote sensing
  - Describe our sample DL-based fusion codes for these applications
- Open Questions and Discussion about the challenges and research opportunities for developing DL-based fusion(20 min)

3 Description of the target audience

This tutorial motivates and explains a topic of emerging importance for computer vision, and it is particularly devoted to: people who want to become aware of DL-based multisensor fusion architectures and learn the fundamentals; people doing research in computer vision and sensor fusion applications and wish to learn how the DL models can be effectively used in such applications. No knowledge of the tutorial topics is assumed. We will focus on basic understanding of DL concepts and models so that tutorial attendees, without prior experience in deep learning, could extend/use effectively DL methods and publicly available code. We except have about 15 people at our tutorial as deep learning has widely used in sensor fusion.

4 Related recent tutorials and publications

- F. Farahnakian,\Maritime Situational Awareness through Multi-sensor Fusion", Turku.AI meetup, Finland, 2023.
- F. Farahnakian, \Deep Learning for Data Fusion\, Tutorial of IEEE International Conference on Data Science and Advanced Analytics (DSAA), 2021.
- F. Farahnakian, and J. Heikkonen, The Second International Workshop \Application of Multi-Sensor Fusion Technology for Autonomous Driving", IEEE 24rd International Conference on Intelligent Transportation Systems (ITSC), 2021.
- F. Farahnakian, and J. Heikkonen, The First International Workshop \Application of Multi-Sensor Fusion Technology for Autonomous Driving", IEEE 23rd International Conference on Intelligent Transportation Systems (ITSC), 2020.
- F. Farahnakian, Tutorial of \Deep Convolutional Neural Networked-based Multisensor Fusion for Computer Vision:Opportunities and Challenges", The 23rd International Conference on Information Fusion (Fusion), 2020.
- F. Farahnakian, "Object detection, classi cation and tracking in autonomous vehicles", DELTA workshop, 2019.
- F. Farahnakian, L. Zelioli, and J. Heikkonen, \Transfer Learning for Maritime Vessel Detection using Deep Neural Networks", The 24th IEEE International Conference on Intelligent Transportation Systems (ITSC), 2021, USA.