Demo: Video-based Social Distancing Evaluation in the COSMOS Testbed Pilot Site

Mahshid Ghasemi*†, Zhengye Yang*‡, Mingfei Sun†, Hongzhe Ye†, Zihao Xiong†, Javad Ghaderi†, Zoran Kostic†, Gil Zussman†
†Electrical Engineering, Columbia University, ‡ Electrical, Computer, and Systems Engineering, RPI
{mahshid.ghasemi,ms5898,hy2610,zx2273,jghaderi,zk2172,gil.zussman}@columbia.edu,{yangz15}@rpi.edu

Abstract

Social distancing can reduce the spread of coronavirus. Hence, we used the PAWR COSMOS wireless edge-cloud testbed in New York City to design and evaluate two different approaches for social distancing analysis. The first, **Auto**mated video-based **S**ocial **D**istancing **A**nalyzer (**Auto-SDA**), was designed to measure pedestrians compliance with social distancing protocols using street-level cameras. However, since using street-level cameras can raise privacy concerns, we also developed the **B**ird's eye view **S**ocial **D**istancing **A**nalyzer (**B-SDA**) which uses bird's eye view cameras, thereby preserving pedestrians' privacy. Both Auto-SDA and B-SDA consist of multiple modules. This demonstration illustrates the roles of these modules and their overall performance in evaluating the compliance of pedestrians with social distancing protocols. Moreover, we demonstrate applying Auto-SDA and B-SDA on videos recorded from cameras deployed on the 2nd and 12th floor of Columbia's Mudd building, respectively.

CCS Concepts

• **Computing methodologies → Object detection**; **Activity recognition and understanding**; **Tracking**.

Keywords

Social distancing, COVID-19, Object detection, Tracking

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1 Introduction

Social distancing is one of the tools to reduce transmission of the SARS-CoV-2 virus. Therefore, we used the NSF PAWR COSMOS wireless edge-cloud testbed, which is being deployed in West Harlem, New York City (NYC) [5, 10, 12], to design and evaluate two social distancing analyzer pipelines, Auto-SDA and B-SDA.

The **Auto**mated video-based **S**ocial **D**istancing **A**nalyzer (**Auto-SDA**) pipeline uses street-level cameras to measure the distance between unaffiliated pedestrians (i.e., pedestrians who do not walk together as a social group) and assess if they maintain 6 ft distance. We applied Auto-SDA on videos recorded before the COVID-19 outbreak, soon after the lockdown, and after the vaccines became broadly available. The detailed results appear in [6].

Although Auto-SDA can detect social distancing violations with high accuracy, using street-level cameras may raise privacy concerns. Therefore, we developed the **B**ird's eye view **S**ocial **D**istancing **A**nalyzer pipeline (**B-SDA**) which covers a larger surveillance area and monitors social distancing compliance without privacy concerns. Videos recorded by bird's eye view cameras result in small and potentially blurry pedestrians. To address this, we developed a real-time processing pipeline which accomplished comparable accuracy of pedestrian detection and tracking to the street-level camera. More details appear in [13].

Both pipelines rely on an object detector and a tracker. However, to achieve highly accurate social distancing analysis, both of them also include specifically designed modules. In this demo description, we briefly discuss the architectures of Auto-SDA and B-SDA, and their modules. In our demonstration, we will present the results of applying Auto-SDA and B-SDA on the videos recorded from COSMOS cameras shown in Fig. 1(a).

2 Auto-SDA Pipeline

Auto-SDA is designed to be a highly accurate social distancing analyzer pipeline, whose performance is not sensitive to the camera's tilt-angle and scene dynamics. The

*These authors contributed equally.

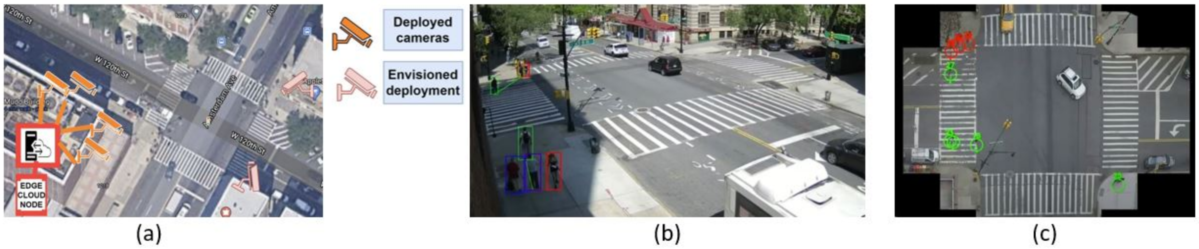

Figure 1: (a) The NSF PAWR COSMOS site at 120th St. and Amsterdam Ave. intersection, NYC; Social distancing evaluation using (b) Auto-SDA and (c) B-SDA (Green: distance < 8 ft; Blue: social group; Red: distance < 6 ft).

pipeline consists of multiple modules, including an object detection module (YOLOv4 [2]) and a tracking module (Nvidia DCF-based tracker). While these are off-the-shelf components, achieving high accuracy calls for the design of tailored components. Specifically, we incorporated three modules in Auto-SDA, as outlined below (see [6] for more details):

- **Camera calibration module:** Calculates the on-ground distances between pedestrians with less than 10 cm error.
- **ID correction module:** Compensates for the inaccuracies of the object detector and tracking models caused by the camera's tilt angle and the obstacles on the road.
- **Group detection module:** Detects the pedestrians affiliated with a single social group.

Fig. 1(b) demonstrates social distancing analysis using Auto-SDA (a sample video appears in https://bit.ly/2Rt36S2).

There have been several recent efforts to employ new technologies and street-level cameras for social distancing evaluation [3, 4, 7–9, 11]. Detailed comparison between Auto-SDA and related work appears in [6].

3 B-SDA Pipeline

The B-SDA pipeline consists of the following steps (see [13] for more details):

- **Data pre-processing module:** Contains 3 components: Weighted-Mask Background Subtraction, Video Calibration, and Center Cropping. This module aims to improve the detection of moving objects, and enlarge per-pixel size of extracted features.
- **Object detection module:** Consists of a modified version of YOLOv4 [2, 13] detector, customized to better detect small pedestrians recorded by a bird's eye view camera.
- **Multiple object tracking module:** In a bird's eye view, object occlusions barely occur, as opposed to frequently occurring in other views (where they pose major hurdles for continuous detection). Considering the accuracy-speed trade off, the module uses the SORT algorithm [1] and achieves both satisfying accuracy and fast inference speed.
- **Group detection module:** Determines social groups and social distancing violations based on trajectory stability and pedestrians velocity similarities.

Fig. 1(c) demonstrates B-SDA's evaluation of social distancing violations (a sample video appears in https://bit.ly/3yGD0Mw).

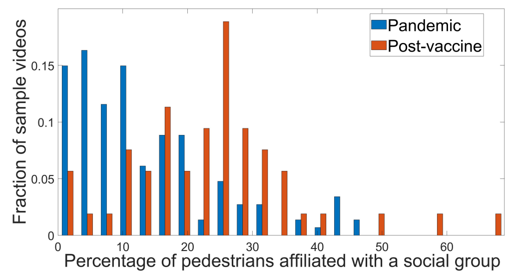

Figure 2: Auto-SDA: Normalized histogram of the percentage of pedestrians affiliated with a social group.

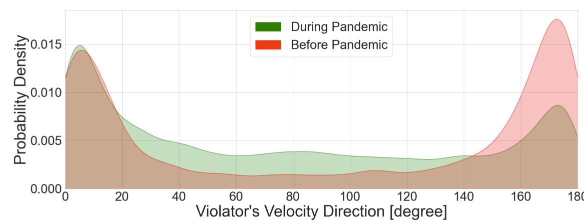

Figure 3: B-SDA: Distribution of the angle between moving directions of two pedestrians in a violation pair.

4 Demonstration

In this demo, we will present the architectures of Auto-SDA and B-SDA and show their use of inputs from street-level and bird's eye view cameras to assess pedestrians' compliance with social distancing policies. We will also discuss the design challenges related to using the COSMOS cameras to perform social distancing analysis. We will visually present the results of applying Auto-SDA and B-SDA on our data-set collected by the COSMOS cameras located on the 2nd and 12th floor of Columbia's Mudd building, respectively. The data-set consists of videos recorded before the COVID-19 outbreak, soon after the lockdown, and after the vaccines became broadly available. The results are representative of the impacts of social distancing policies on pedestrians' social behavior (see Fig. 2 and Fig. 3 for examples of these results corresponding to Auto-SDA and B-SDA, respectively).

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