Objectively measuring how clean our cities are

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Credit: EPFL

EPFL researchers have come up with a fact-based system to measure urban cleanliness. Municipal authorities will now be able to draw on objective assessments when planning their street cleaning – a sector with multi-million-franc budgets.

The concept is straightforward: on one hand, vehicles equipped with

video cameras to record the city streets, and on the other, a computer able to spot waste, identify it and classify it – in the blink of an eye. A researcher from EPFL's Signal Processing Laboratory 5 (LTS5), working with local startup Cortexia, the Haute Ecole Arc and several Swiss cities, has created a system that provides cities with an objective way of assessing the cleanliness of their streets, including detailed information on the amount, type and location of waste. The system should help them decide which and how many street sweepers to purchase, how often to clean the streets, and which areas need to be cleaned more often because they are dirtier or because the garbage there is more dangerous. With a fact-based assessment at their fingertips that showed what sort of trash is located where, and which areas are hardest hit, city officials would be able to implement much more efficient – and potentially much less expensive – street-cleaning programs. That's the approach described in an article appearing in Computer Vision Systems.

A definition of cleanliness based on human perceptions

In the absence of quantifiable and scientific criteria, city officials rely on human perception when it comes to setting up street-cleaning programs. "It's a key factor for cities in Switzerland and in Europe more generally, because it affects residents' quality of life and has a bearing on how attractive cities are for both tourists and businesses," says Mohammad Saeed Rad, a scientific assistant at the LTS5. "But cities today don't have the objective metrics they need to manage their waste." Every city has its own approach to assessing the cleanliness of its streets. Zurich does this by sending people out several times a year to walk the streets and record the trash they encounter – bottles, cigarette butts, etc. Others do it by asking residents to rate various parts of town for cleanliness.

The system recognizes every object and classifies it in the correct category. Credit: Ecole Polytechnique Federale de Lausanne

To obtain the fact-based assessment needed, the researcher's system uses vehicles equipped with high-definition video cameras to record city streets and all the objects on them. A computer then analyzes the images using special software to identify each object, determine if it is waste and, if so, assign it to one of 25 categories labeled as "waste" – e.g., plastic bottles, newspaper, cigarette butts or leaves. The researchers used machine learning to 'train' the computer to recognize and categorize various types of waste. They showed the computer as many images of as many types of waste as possible so that it can recognize them all. "We are still improving our results by feeding the database," says Rad. The more types of waste the computer sees, the fewer mistakes it will make in recognizing and categorizing it.

The researchers had their work cut out for them, since the computer has to be able to recognize two-centimeter-long cigarette butts, for example, in images taken several meters above ground at a speed of two frames per second. "At first, we decided to mount the cameras on the top of the city's street sweepers, since they are sure to visit the dirtiest parts of town," says Rad. "We then realized, with our partner cities, that these vehicles could not be driven in a number of important areas like parks and playgrounds. So we came up with a bicycle-mounted version of our system." The researchers ran tests in the rain and in the early light of dawn to gauge system improvement.

The researchers developed an index composed of 25 types of waste. Using this index, cities can customize their waste analysis methods, picking and choosing from standard criteria. "City officials can choose the categories they want to include in their assessment, depending on which ones they consider waste and what street-cleaning resources they have," says Rad. For both Rad and Cortexia, it was important to link object recognition to a response. "Glass shards are more dangerous than chewing gum and should probably be cleaned up first," says Rad. "Along the same lines, certain types of waste are evaluated differently depending on whether they are hidden away somewhere or located in a park where children play."

More information: Mohammad Saeed Rad et al. A Computer Vision System to Localize and Classify Wastes on the Streets, *Computer Vision Systems* (2017). DOI: 10.1007/978-3-319-68345-4_18

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