Crowd Control - Using artificial intelligence to track people counts in near real-time

Project Goal

With the increasing degree of urbanization, more and more people are concentrated in cities. Especially community events, such as sport events, concerts, festivals and conferences, lead to thousands of people located at a limited amount of space. The tracking of the number of people plays a significant role for the security and management of cities and facilities. Apart from the pure count, the distribution of people is very important in order to estimate the risk of possible mass panics and riots.

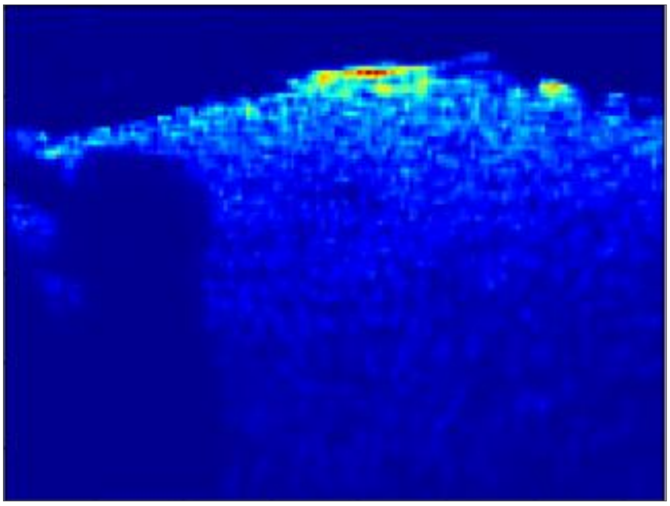
The aim of this project was to develop an artificial intelligence, that allows for a quick and accurate estimation of the number of people in diverse imagery. The AI also allows for a direct estimation of the people distribution. This tool can be used to conduct real-time tracking of people counts and distributions in crowded places.

Provided Data

The image data, that was used for training the artificial intelligence, consists of 1,198 images depicting crowds of people. In total 330,165 people were present in those images and their head was annotated as training labels. The images were partially crawled randomly from the internet and partially taken from busy streets of metropolitan areas in Shanghai.

The images vary a lot in crowd density and camera angle. 700 of those images were randomly chosen for training and 498 were taken for validation and testing purposes.

Sample test image, taken from the Love Parade in Düsseldorf



Predicted density of people in the image to the left
(Predicted visible people count is 2713)

Challenges

The main challenges in the crowd counting task are the many variations of appearance, perspective, illumination, crowd density and distribution. In terms of performance (speed and accuracy) traditional AI solutions for detecting objects in images suffer a lot when it comes to the detection of too many objects per image.

Applied Methods

To approach the problem of varying crowd densities and distributions and the high number of objects per image, a density-based approach is considered. In effect, the prediction target of the AI is the density of people on a per-pixel basis. For this purpose a neural network architecture, called CSRNet, was implemented. The network is composed of two components. A convolutional neural network (CNN) is used for extracting features in the images. The second component is a dilated CNN, which uses dilated kernels to deliver larger reception fields.

Generating Training Data

The provided data consisted of images of people crowds with their heads labeled. The input and output of our approach needed to be a density map of people in the image. To achieve this, a geometry-adaptive kernel was applied to the annotation map and a Gaussian kernel for blurring out the density. Data augmentation to increase the training set size was applied by using image patching, mirroring and blurring.

Performance

The predicted crowd densities resembled a close spatial relationship compared to the ground-truth densities in the unseen test set. In the test set with 115,905 people, the average was 252 people per image. The average absolute error of the prediction per image was 12. Therefore the prediction with around 5 % uncertainty is very low and the accuracy quite impressive.

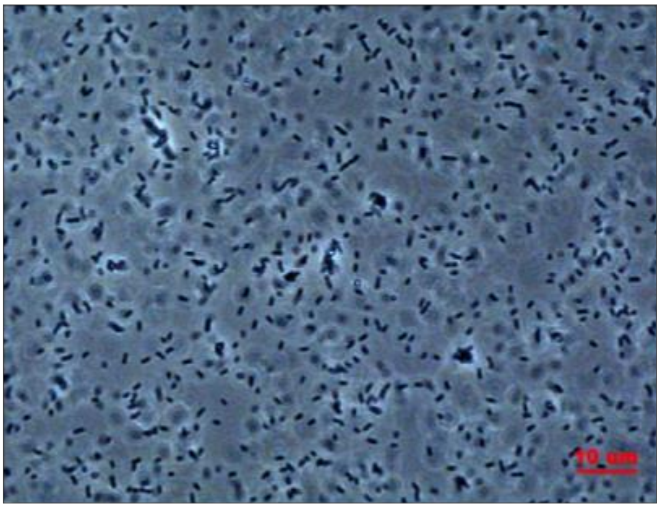
Project Outcome

The developed tool is able to accurately estimate the number of people in large crowds shown in images. This can be used to do near real-time monitoring of crowds. Apart from that, the predicted density map of the crowd can be used to asses potential risks and bottlenecks in security planning.

Further applications

The concept of crowd count and density estimation and the derived tool can be extended to the use in a variety of applications. One example is the counting and the estimation of plant density of crops and vegetation in general, where large amount of planting / growing areas need to be monitored. The chemical and biological area has many potential applications, such as the counting and density estimation of cells or bacteria.

Labeled image of maize tassels



Sample image of cells