Image Based Gait Analysis Of Rats Treated With Botox

KØBENHAVNS UNIVERSITET

Lise Aagesen & Sophie Nielsen

University of Copenhagen & Technical University of Denmark

DTU

Introduction

Every year app. 140 children are born with cerebral palsy (CP). The disorder is a neuromuscular disease that causes sustained contractions in the affected muscles, leading to abnormal posturing and movement disabilities.

Botox is a frequently used pharmaceutical in the symptomatic treatment of CP. Botox, when injected into the muscle, prevents it from contracting at all and thus leaves it totally relaxed.

The Botox treatment is, however, yet on a stage where its long-term side-effects have not been fully examined in a controlled study. At the Panum institute (University of Copenhagen) such a study is being conducted using rodent experiments. Botox is injected into one of their legs and after the injection the rat is observed over a period of two months. One of the tests being carried out is gait analysis.

As for now the gait is being analyzed by using ink and paper as seen on figure 1. Parameters such as trot area and angles of the paws can be calculated from the prints, which are manually analyzed. As this is time consuming there is a need for a more automatic analysis tool. The purpose of this project is to examine the possibilities of the development of such a tool.

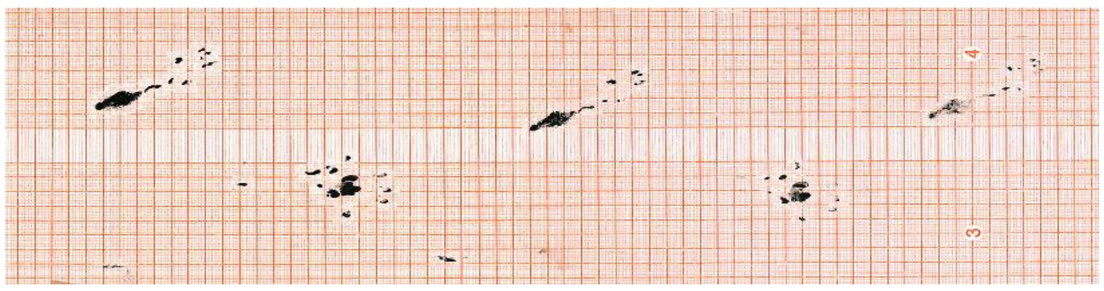


Figure 1: Ink-made footprints from Botox injected rat

Methods

Setup

The ink-and-paper method is substituted by a video based approach. The rat walks through a glass tunnel which is being recorded from below (see figure 2).

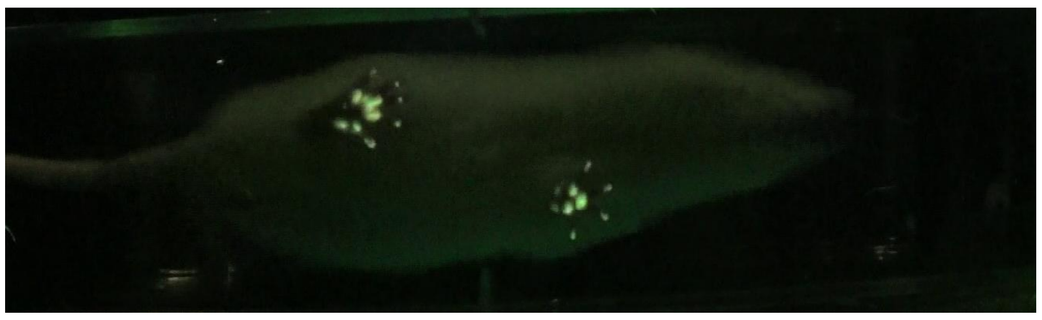


Figure 2: Image from the original video

Thresholding

To detect the paws in the video, they have to be isolated. This is done by doing a threshold on every image, leaving a binary image with only the brightest pixels left. The threshold value is determined using the distributions of the pixel values of the different classes in the image (background, body, and paws). Figure 3.a shows the values of selected pixels from the three classes plotted in 3D.

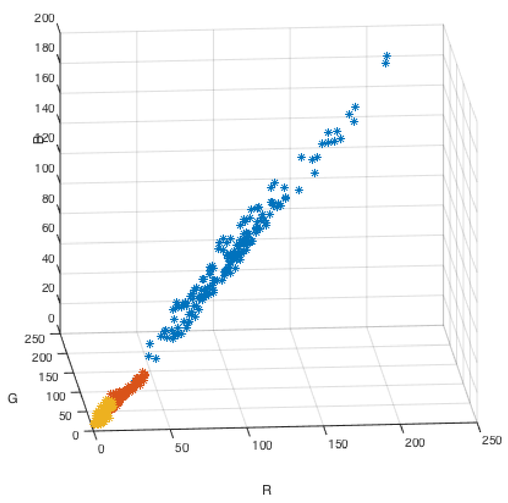


Figure 3a: 3D plot of selected areas

By doing a principal component analysis (PCA) on the values, the one-dimensional line, on which most of the variance in the pixel values is explained, can be found. Assuming the values are normally distributed, a probability density function (PDF) can fitted to every class, as seen in figure 3.b.The threshold value can then be estimated by calculating the intersection of the fitted PDF's.

The results from the intersection of the normal densities were compared to results from Otsu's method and they turned out to be very similar. To distinguish between the classes we assume that they follows a normal distribution and estimate parameters. Figure 3.b shows the data and the fitted distributions.

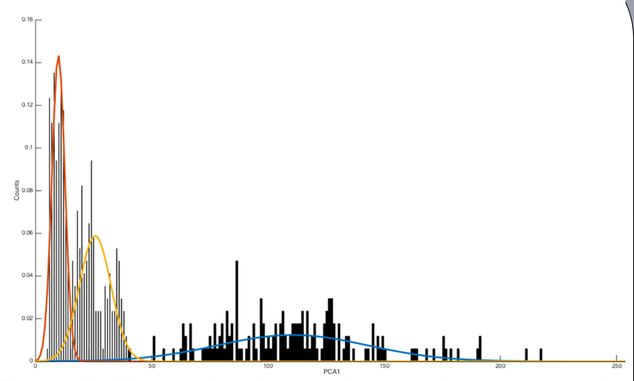


Figure 3b: Normaldistribution of pixelvalues in greyscale

Paw Detection

To analyze the gait it is necessary to locate the paws in each frame. This can be done using blob detection with a difference-of-Gaussians approach. The approach highlights the details of the image and reveals the single paw as a highlighted area rather than separated spots. With the right kernel size of the filter, the paws will be the most highlighted items in the image making it easy to locate them.

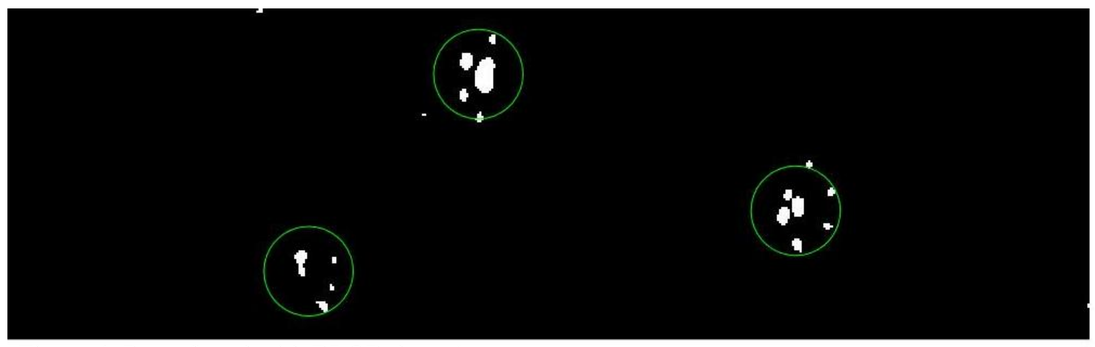


Figure 4: Paws found with BLOB detection

To enable individual analysis of each paw the paws have to be located separately. In this way the dynamics of the paw affected by the Botox injection can be observed over time.

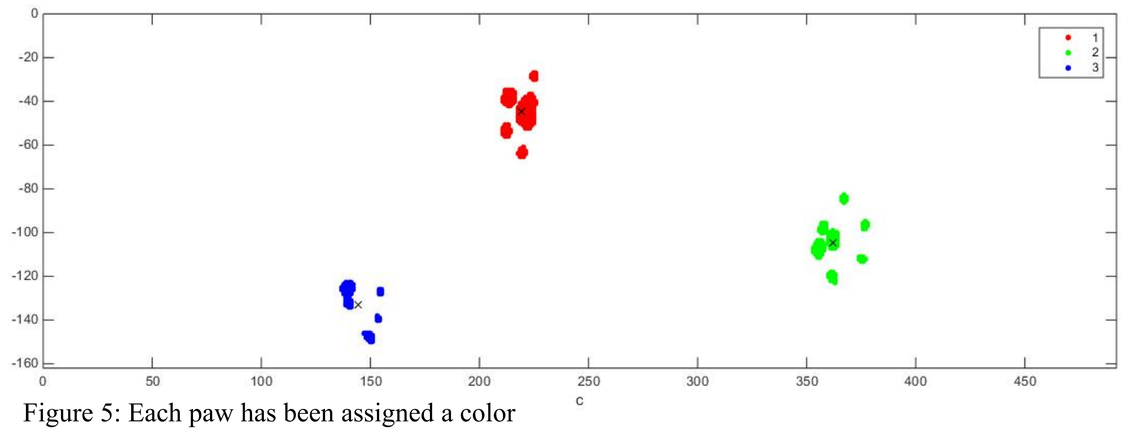
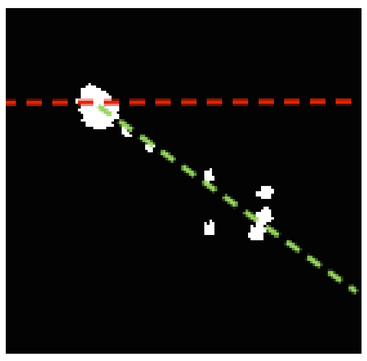


Figure 5: Each paw has been assigned a color

Parameters to examine



As a part of the study, different parameters wished to be found. Among these parameters are the angle and the area of the paws. These parameters will be analyzed during the experiment as well as the development in the gait over the time period of two months. In figure 6 is shown a possible way to find the angel.

Figure 6: Marking the angle

Discussion

This analysis tool removes part of the manual work done in the gait analysis, and the data is digital, making it more convenient to store and to work with. But the method meets some challenges. A more intense lighting could improve the ability to extract the paws without having to cut part of them out along with the rest of image. Moreover the rats are not necessarily of the same size, and they grow in both size and weight during the two months, which makes the trotting area vary from the beginning to the end of the study. This makes it more complicated to make a robust algorithm.