Kinect Assisted Rat Behaviour Analysis for Experiment Automation

Authors:
Cagri Sofuoglu

Ismet Burak Kadron

Advisor:
Albert Ali Salah

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This is to certify that this is a bonafide record of the project presented by the students whose names are given below during Spring 2014 in partial fulfilment of the requirements of the degree of Bachelor of Science in Computer Engineering.

Roll No	Names of Students
2010400078	Cagri SOFUOGLU
2010400093	Ismet Burak KADRON

Albert Ali SALAH
(Advisor)

Arzucan OZGUR
(Course Coordinator)

Date:15.04.2014

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Abstract

Video tracking systems enable behavior to be studied in a reliable and consistent way, and over longer time periods than if they are manually recorded. The system takes an analog video signal, digitizes each frame, and analyses the resultant pixels to determine the location of the tracked animals (as well as other data).Prof. Resit Canbeyli and his fellow researchers at the psychobiology Lab at Bogazici University enlisted our help in building a reliable system with which to track their subjects: rats. This document describes our effort in creating a object tracker for both light and dark environments with the depth data Microsoft Kinect provides. The 2D depth images are searched for closed contours which are then marked as objects. In our case these objects are the rats Prof. Resit Canbeyli and his co-workers wish to track under all lighting conditions. Here, our progress as of midterm report deadline and planned future work are described.

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Chapter 1

Problem Definition

Video tracking for purposes of behaviour analysis has been used by the researchers at Psychobiology lab extensively. One such system currently in use is EthoVision (from Noldus Information Technology). Which provides detailed analysis tools to researcher when tracking lab rats. But one limitation of the EthoVision is its inability to operate under lowly lit or dark environments. This limitation became relevant when Prof. Resit Canbeyli enlisted our help in designing a tracking system with similar functionality but can operate under lighting situations representing both daylight and night conditions. This system is going to be used in an experiment where day/light periods are manipulated to observe changes in the rats biological clocks.

Thus we decided the depth images provided by the Kinect made the perfect sensor for the task, as the data is unaffected by any light emission within human visual range.

The problem then becomes finding closed contours in the depth image and tracking resulting objects.

Chapter 2

Introduction

2.1 Background and Recent Research

2.1.1 Background

Psychobiology researchers in Bogazici University conduct extensive animal tracking experiments. These experiments are sometimes conducted with experiment automation tools like EthoVision from Noldus Software. But such software currently in use has the limitation of daylight lighting conditions.

To be able to conduct experiments that span over the full day/night cycle, they were in need of systems capable of object tracking under no light conditions.

2.1.2 Literature Survey

EthoVision Video Tracking System [1]

Video tracking systems enable behavior to be studied in a reliable and consistent way, and over longer time periods than if they are manually recorded. The system takes an analog video signal, digitizes each frame, and analyses the resultant pixels to determine the location of the tracked animals (as well as other data). Calculations are performed on a series of frames to derive a set of quantitative descriptors of the animal's movement.

Validation of a digital video tracking system for recording pig locomotor behaviour [2]

The authors are introducing a system for automatically tracking pig locomotor behaviour. Transposing methods for the video-based tracking of rodent behaviour engenders several problems. The authors propose a method which improves existing methods, based on image-subtraction, to offer increased flexibility and accuracy in tracking large-sized animals in situations with a constantly changing background.

Automatic real-time monitoring of locomotion and posture behaviour of pregnant cows prior to calving using online image analysis [3]

Monitoring the locomotion and posture behaviour of pregnant cows close to calving is essential in determining if there is a need for human intervention to assist parturition. In this study an automatic real-time monitoring technique is described in detail which allows identifying the locomotion and posturing behaviour of pregnant cows prior to calving.

2.2 Motivation

This project aims to provide researchers with a tool to create, repeat and document animal tracking experiment results in a credible way.

It is meant to provide users with unbiased and structured behaviour analysis reports.

Chapter 3

Work Done

3.1 Progress Made By Project Midterm

3.1.1 Image Slicing

The data drawn from the Kinect is in 2D depth image format. Which is a grey-scale image where the distances of all points are represented by a single value. The closer the surface the brighter it shows on the image.

The problem with the structure of the raw data is, when the objects are very close or very similar in height the differences corresponding to respective surfaces become too subtle to extract object from. In those cases the data raises false positives.

To alleviate this, we used image slicing. Image slicing is an image processing technique where pixel values outside certain regions are reduced to zero.

As shown in figure 3.1, by fading all areas outside a certain region to black objects within that region are depicted with much more contrast since the dynamic range is focussed on a much smaller area.

With this false negative are removed but the calibration is of utmost importance. If the regions near and far borders are not determined properly desired objects are lost completely.

3.1.2 Blob Tracking

As the main aim of the project is object tracking, we directed most of our effort to this area.

Once the depth image from the Kinect is cleaned up we extract the contours of the image and encapsulate them in rectangles which are inner representations of the captured objects as shown in figure 3.1.

This part is implemented with the help of OpenCv libraries which provides helper functions for both jobs: extracting contours and marking them.

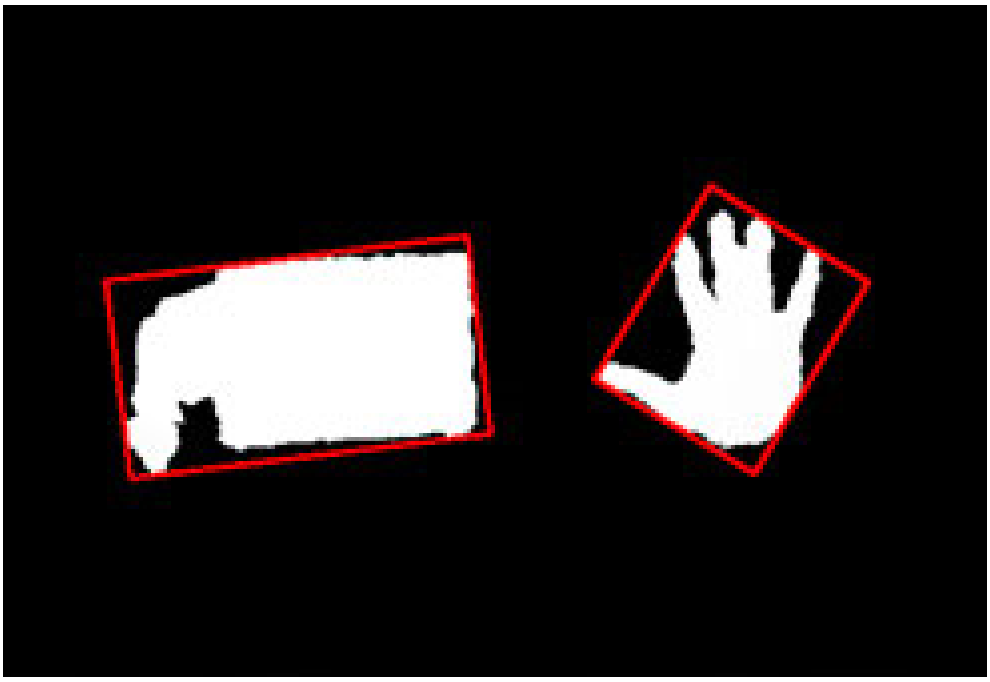


Figure 3.1: Sliced image with objects marked

3.1.3 User Interface

As a prototype a UI is built to track objects with Kinect. This program while recording the processed video, slices the image, isolates the objects.

As shown in figure 3.1, the relevant UI element are the sliders to calibrate far and near borders for the slicer and max/min blob sizes.As of nbow calibration of these variables are done by hand and are very important to properly isolate objects to be tracked.

3.1.4 Multi-Threading

For performance purposes we chose to separate video record and object tracking functionality to their ow threads. this significantly improved performance as these functions were no longer impeded by each other and the UI load.

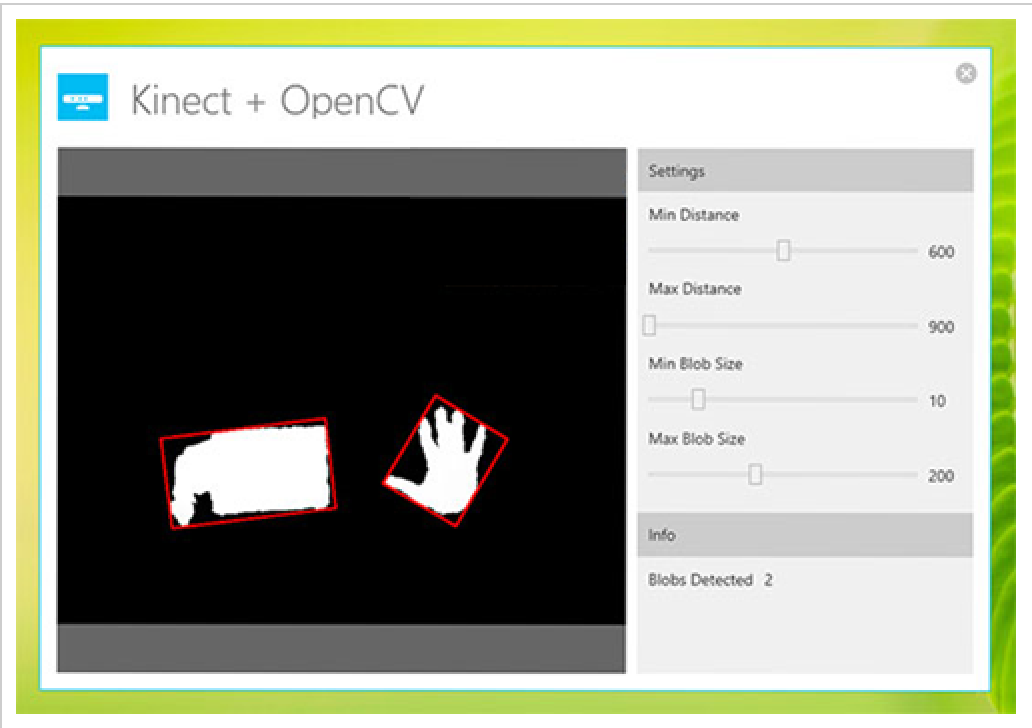


Figure 3.2: Prototype User Interface

Chapter 4

Future Work

As of the composing this document, the project is still in prototype stage. This project is meant to produce an easy to use experiment automation software.

4.1 Functionality To Be Added

4.1.1 Behaviour Analysis

This software will provide users all data such as:

- mean of position
- standard deviation of position
- position history
- active time periods
- inactive time periods
- areas highly frequented by the subject animal

and any other report our product owners may require.

4.1.2 Experiment Setup

We will implement a "New Experiment" Wizard which will guide the end-user through creation of automated experiments.

Default parameters for the Wizard will be determined to make this process as streamlined as possible.

4.1.3 Performance Improvements

Currently the system is working with 30fps framerate which gives us roughly 33 ms to track objects, log data and record the processed video. As of the project midterm the program is a bir resource heavy and works with occasional lag.

We will reduce runtime load by running object tracking on image pyramids instead of raw data.

By using image pyramids we will first determine rough locations of objects on a much lower resolution image and work our way up for parts that seem to contain objects. Thus relieving the system of unnecessary load of scanning empty areas in high resolution.

4.1.4 Offline experiments

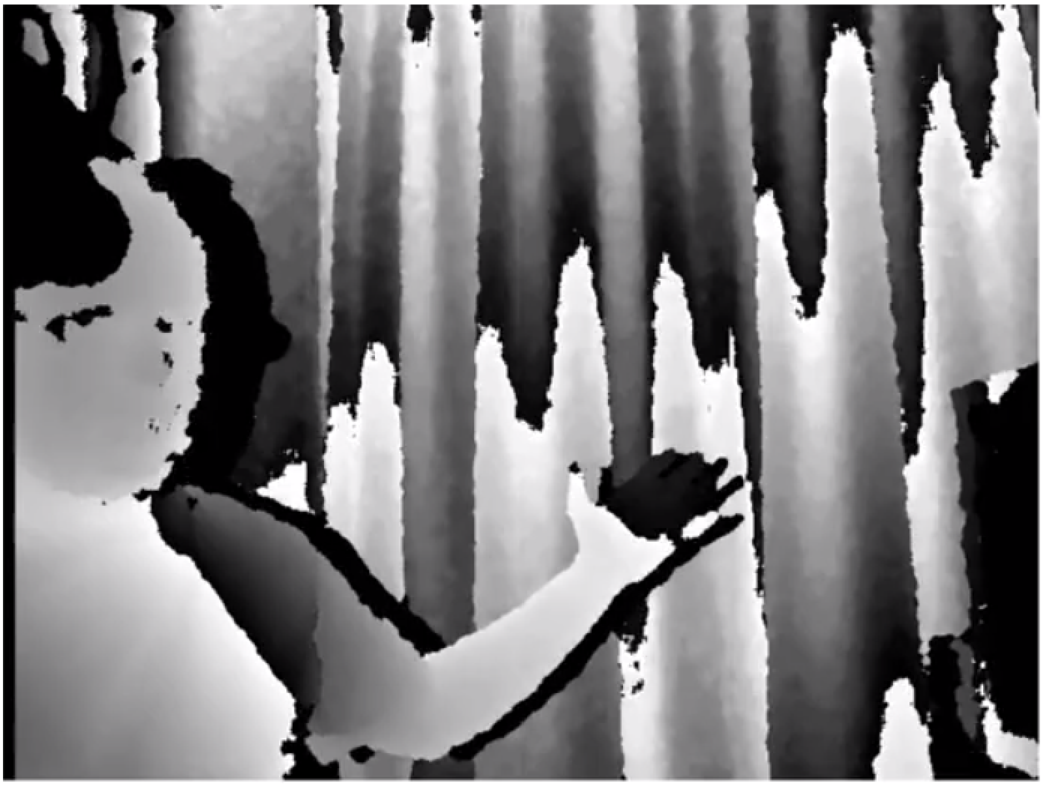
One of the functionalities we aim to implement is running the same experiment off-line at a later time.This functionality is essential since this product is meant for scientific purposes which require a certain degree of repeatability.

By providing the user with off-line experiments any user can check and validate another's experiment which brings credibility to experiments.

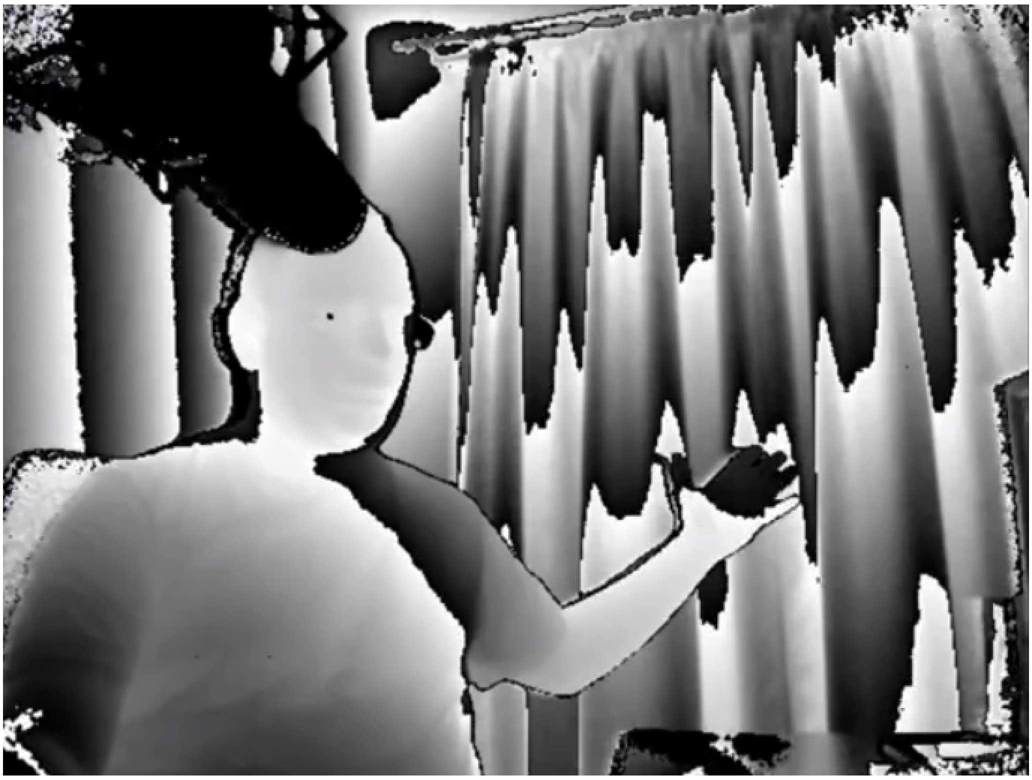
4.1.5 Exploring Kinect 2

In early 2014 Microsoft released its successor to Kinect, Kinect 2 which has much higher resolution output and very high performance as shown in figure 4.1.

We will explore Kinect 2 as a new sensor. If the extra resolution doesn't hit performance too hard we will consider switching to it to be able to work with much cleaner data.



(a) Kinect



(b) Kinect 2

Figure 4.1: Kinect Output vs Kinect 2 Output

Chapter 5

Conclusion

We are introducing a system for automatically tracking rat locomotor behaviour for experiment automation. We explored the advantages of using Kinect over classical RGB cameras since this approach allows for the system to operate without concerns over lighting conditions.

This solution was deemed necessary because the product owners, researchers at the psychobiology lab, require the ability to track and observe subjects in bot day and night conditions.

In this document, the effort that was put into this task as of Project Midterm date is documented. Lastly, planned future work is also described.

Acknowledgments

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