# Introduction

Today there are relatively many mobile applications for expense tracking. It goes without saying, that one of the core features that all the expense tracking applications have is a possibility to manually submit basic expense information (eg. total sum, merchant/company etc.). But with the development of modern technologies, some expense tracking applications introduced an opportunity to take pictures of purchase receipt in order to automatically recognize and extract basic expense information from the image and place the extracted information into user’s expense list inside the application. From the users’ perspective, such functionality may be quite useful, as it prevents them from manual expense submission in favor of automatic receipt processing. The most well-known examples of applications of such kind are Expensify[1] and Xpenditue[2]. But at the same time, these applications are proprietary and what is more, they are not free of charge when it comes to extensive usage of expenses extraction from receipt image. By the time the author started with this thesis, he has not found any noted open-source expense tracking software with the functionality of expense recognition from a receipt image. Because of this, the author decided to implement such mobile application, which would allow expense data recognition from images of receipts issued in Estonia, using open-source technology stack.

## Problem and background

The main problem the author focuses in this work is to find out the best designing solution for expense tracking mobile applciation, focusing on possibility of expense information recognition from Estonian receipts as well as usability and security aspects of the applicaiton.

The reason why this work may be considered useful for the broader audience is that as a result of it appered a mobile application, which can simplify users’ everyday expenses tracking and thus to help planning personal budget more sensibly.

The knowledge gained during development of this applciation and pointed out in this work may be useful from the perspective of a software engineer, as it covers the following topics:

* Comparison of potential solutions regarding the architecture and design of such kind of application
* Methods of receipt image processing in order to improve recognition of the text from receipt
* Reliability evaluation of the application’s function of expense information recognition from the aspect of Tesseract for OCR and OpenCV for image preprocessing usage.

## Goals

The main goal of this work is to implement a mobile application with the following functionality:

1. Possibility to take picture of a receipt, recognize total sum of the purchase and the company the purchase was from based on the receipt image, compose an expense entry from this information an place it into user’s expense list.
2. Possibility for the user to see his own expenses.
3. Possibility to insert expense entry manually, which can be useful in case recognition of expense from receipt has failed due to some reason.
4. Possibility to make pictures of receipts while device is not connected to the internet and make expense recognition from those pictures later.
5. Graphics? (to be implemented)

## Methodology

To achieve the goal the author implemented the Android client-side application and the server side application written in Java programming language. Both client and server are designed in an object-oriented manner. The server side is put to communicate with the database (PostgreSQL) and an external web serice of the e-business register. Both service and client are also using third-party libraries.

## Thesis overview

//to do: add when is ready.

# Theory

## Image preprocessing

In the author’s mobile application, the picture of receipt used for further exepnse information extraction is taken with the help of the mobile device’s camera. As not all the mobile phones have high resolution cameras, this means that the quality of the captured receipt image itself may not be good enough to perform successful optical charecter recogniton. Besides that, the recognition stage is made even harder by the fact that cash registers use mainly either thermal printers with thremal paper or dot matrix printers for receipt printing. The problem of the receipts printed with the thermal printer is that they tend to fade with time, and the problem of the dot-matrix-printed receipts is that the charecters are composed of small dots, which makes it hard for the OCR engine to determine them correctly. As a result, in order to enchance the quality of the image with the purpose of better OCR results, image preprocessing shoulde be done.

The first measure to be taken is order to enchance image for further OCR is converting color image to grayscale. This is important because it helps to increase recognition accuracy as well as the recognition speed by the OCR engine (<http://research.ijcaonline.org/volume55/number10/pxc3882784.pdf> p. 52).

The second stage of preprocessing is noise removal. Noise is considered to be either error in the pixel value or an unwanted bit pattern with non significance in the output image, which is introduced due to reproduction or transmission of image during its acqusition process. The noise may be amplified by the digital corrections of the camera or tools removing blur or increasing contrast of the images. The most trivial denoising method is quite trivial - replacing the color of the pixel with an average of the colors of nearby pixels. But in practice, it doesn’t work that well, as similar pixels are not always close to each other.  It is therefore licit to scan a vast portion of the image in search of all the pixels that really resemble the pixel one wants to denoise. Denoising is then done by calculating the average color of these most similar pixels. The similarity is evaluated by comparing a whole window around each pixel, and not just the color. This new filter is called non-local means. This filtering method is availabe in the OpenCV

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