**Project in Applied Mathematics, FMAN40, 2016**

This document contains information about the project course in Applied Mathematics and suggestions for projects. The list of suggested projects is brief. More projects may be posted/updated on the web-page: [http://www.maths.lth.se/matematiklth/personal/kalle/projekt/](http://www.maths.lth.se/matematiklth/personal/kalle/projekt/).

There you will also find information of dates, deadlines and such. For further information and for material contact the supervisors of the project.

1. **Image analysis of jellyfish images for modelling of jellyfish**
   In an ongoing collaboration with the vision group at the department of Biology, we would like to model the visual processing and motor feedback of jellyfish. In this project the aim is to perform feature detection on image sequences of jellyfish to measure their motion, while controlling their visual input.
   Contact: KÅ, MO.

2. **Tracking multiple objects using multiple cameras**
   To automatically explain what’s going on in a scene by extracting trajectories of everything moving in the scene is of interest in several cases. It can be used to assess traffic safety, study how people utilize public places, provide safety systems for industrial robots. We have several datasets which could be used in this project including a month recording from an intersection in Minsk from 6 cameras.
   Contact: HA, MN.

3. **Material analysis of asphalt**
   The centre for mathematical sciences are involved in a project together with PEAB asphalt in Helsingborg. There is an interest in material properties and how e.g. the bitumen mixtures, chemical additives, the shape and material properties of the stones. The goal of the project is to develop automatic methods to estimate the shape distribution of the stones.
   Contact: KÅ, HK.

4. **Tracking rats for neuroscience**
   The researchers at the Neuronano Research Centre need help tracking rats. Rats are being filmed from the side as they reach for a food pellet. The task is to automatically detect when the rats lift their paw from the floor. The basic idea will be to use foreground-background segmentation. (There are other interesting tracking tasks as well.)
   Contact: TP.

5. **Automated volume estimation**
   The forest industry is technology and knowledge-intensive with high-tech processes and products with high knowledge content. The savings potential is large and therefore the interest in continuous and automatic volume estimation using image image analysis. At the terminals logs and wood chips are stored in large quantities of up to one hundred meters high piles. There is an interest in monitoring these quantities and answering questions like: How many cubic meters of timber there are in stock? How much wood chips are in stock? The accuracy requirements are not very high. There is also an interest in measuring the volume of timber on trucks that arrive to the terminals. Here the requirements on accuracy are higher.
   Contact: HA.

6. **Detecting athletes for performance analysis**
   Athletes study motion statistics in order to improve their performance. Using image analysis it is possible to extract a number of useful features for such studies. Examples include velocity profiles, step lengths. A first step in this direction is the detection of the athletes in the images.
   Contact: HA.
7. Detecting running tracks for sprint events
To automatically record sprint events using a pan/tilt/zoom camera that follows the runners it is important to know where the running tracks are in the image. This allows for a more robust system that can assume that the runners follow those tracks. Also, it could be used to find the start and goal of the track. The lines between the lanes of the running tracks is a strong feature and the positions where these lines are not visible in the image are good candidates for where the runners are currently located.
Contact: HA, KÅ.

8. Systematized pan/tilt/zoom-camera
When recording events using pan/tilt/zoom-camera there are physical limits as to how the camera can move. This puts restrictions on what kind of camera motions are possible. Also, if a mistake is made during the recording of an event, it’s hard to fix that after the event is over. An alternative is to place several fixed cameras at the same location and zoom them in on different parts of the scene of interest. The images from all those cameras can be stitching together and a synthesized ptz-camera image can be generated by cropping and scaling it. If the original videos from the static camera is saved this can be performed offline and allow a producer to experiment with different camera-motions after the event was recorded.
Contact: HA.

9. Fake small depth of field
Images consisting of a sharp foreground object on top of an blurry background appears sharper as compared to an image where everything is in focus. This effect can be faked by segmenting out the foreground object from a sharp image and then blur the background but not the foreground object. By using short video-clips that process can be automated by for example blurring that static background while keeping the objects in motion sharp.
Contact: HA.

10. Object recognition
The goal of the project is to explore methods to detect objects in images, for instance a person, a motorbike or an animal like a dog or a cat. Detection would mean, in this case, placing a bounding-box around the object of interest. Existing methods operate by obtaining a classifier using a large training set of positive and negative examples (bounding boxes of objects of the desired type, as well any other objects or structures, not from that class). At test time, the classifier is run exhaustively at different locations and scales in the image, and a bounding box is reported at the location and scale where this fires. The technology works well for some objects (e.g. faces) but fails for many others, like people in general poses or animals. The goal of the project is to explore different, accurate methods for detection that would be applicable to a more diverse set of object categories. The project is best suited to highly motivated students with a strong mathematical background and excellent programming skills.
Contact: CS.

11. Study pigs in a pen
With increasing volume of animals in agriculture is desired to develop more methods to help the farmer to analyze the animals. This project is focused on the study of pigs in the box using the surveillance camera. Using image analysis it is desired to see if a system can find some behaviour and get the decision support information, such as see if pigs start fighting or see how the group choose placements at different climatic conditions in the box. Finding and/or segmenting out pigs in the box is a first step in this project
Contact: MN

12. Stochastic Monte Carlo Simulation of Vehicular Traffic
We examine, construct and apply stochastic microscopic processes in order to describe vehicle interactions on a given roadway geometry. Through this project we learn to appraise and differentiate between Cellular Automaton or purely stochastic processes as well as simulate them using Metropolis or Arrenhienous dynamics. We focus on three different aspects of the modeling method: a) constructing the
mathematical infrastructure b) simulating the dynamics using Monte Carlo and c) validating the results against reality.
Contact: ASo.

13. **Analysis of swimming based on digital image analysis**
In a newly started company we are developing image analysis algorithm for tracking and analyzing professional swimmers. The proposed project consists of investigating different methods for tracking swimmers in multiple images or counting the number of strokes.
Contact: AH.

14. **Registration of medical images**
The goal of this project is to test and implement methods for registration of medical images, i.e. estimating the transformation between two images or between an image and a model scene. The transformation could e.g. be a rigid transformation or a projective transformation. Using features such as SIFT and robust matching algorithms such as RANSAC robust and accurate registration can be achieved.
Contact: NCO.

15. **Digit recognition**
We have a quite large set of images of digits (1-9). These are taken from many different types of fonts, sizes, quality etc. There is thus a larger (and more realistic) variation of a digit within the set. The aim of this project is to use this database to develop and test robust classification algorithms for digit recognition. The resulting system could incorporated with the sudoku and/or kakuro reader in order to improve the system.
Contact: KÅ

16. **Detection of traffic congestion**
The centre for mathematical sciences and the division of road and traffic technology are working together on algorithms for automatic analysis of road user behavior. One interesting sub-problem is to automatically detect traffic congestion from images. We have access to numerous images taken from cameras owned by the road and traffic authority.
Contact: HA, MN.

17. **Background/foreground-segmentation**
Stationary cameras that are observing objects moving against a more or less stationary background can be detected by so called background foreground segmentation algorithms. The goal of the project is to develop such techniques and evaluate them.
Contact: MN, HA.

18. **Analysis of mammography-data**
The project is aimed at analysing mammography data with deep convolutional neural networks in order to see if modern machine learning techniques can improve on current state-of-the-art in the analysis of such data.
Contact: KÅ.

19. **Deep learning for the analysis of rat speech**
Rats speak in ultrasound range. By studying so called sonograms of the sounds made it is possible to distinguish distinct words and to cluster such words. There is, however, considerable variation that makes such clustering and classification difficult. The goal of the project is to use deep convolutional neural network representations to improve on current state-of-the-art of such clustering and classification.
Contact: KÅ.

20. **Kakuro reader**
Kakuro is similar to sudoku. It’s like a crossword puzzle with integers 1 to 9. The project is aimed at
developing a kakuro reader and solver.
Contact: KÅ.

21. **Identification of digital pen writer.**
In some applications it is interesting to determine which person that is using a digital pen. The input from the digital pen to the computer consists of a series of points with coordinates. In this application it is not necessary to recognize what is written, the focus is on who that is writing. The goal of this project is to investigate different techniques for writer recognition and try them on sample data.
Contact: AH.

22. **Tredimensionell rekonstruktion av tvådimensionell uppklippt sfärisk yta**
Contact: SD, AH.

23. **Evaluation of skin images**
There is a growing interest in telemedicine, e.g. making diagnoses or recommendations from images or other information sent in to a doctor and/or an automatic decision system remotely. In this project, the goal is to analyze skin images in order to evaluate the risk that birth marks are malignant and the risk of developing skin cancer. The project is based on a collaboration with the company Instant Advice.
Contact: AH.

24. **Own suggestion**
You are free to come with your own suggestions on projects. Contact the project coordinator and get your project approved.
Contact: KÅ.

Contact persons (supervisors):
HA Håkan Ardö, ardo@maths.lth.se
SD Stefan Diehl, diehl@maths.lth.se
AH Anders Heyden, heyden@maths.lth.se
MN Mikael Nilsson, mikael.nilsson@math.lth.se
CO Carl Olsson, calle@maths.lth.se
MO Magnus Oskarsson, magnuso@maths.lth.se
NCO Niels Overgaard, nco@maths.lth.se
AS Alexandros Sopasakis, sopasak@maths.lth.se
CS Cristian Sminchisescu, cristian.sminchisescu@math.lth.se
JU Johannes Ulén, ulen@maths.lth.se
KÅ Kalle Åström, kalle@maths.lth..se