Project in Applied Mathematics, FMAN40, 2014

This document contains information about the project course in Applied Mathematics and suggestions for projects. **Deadline for registration** to the project course is **October 21, 2014**.

- Register to the course by sending e-mails both to the supervisors of the project (see list below) and to the coordinator Kalle Åström (`kalle@maths.lth.se`). Deadline for registration is **October 21, 2014**.
- Produce a short, but informative plan for your project work, about 1 page to all supervisors and to the coordinator. The plan should include a timeline of the work. Deadline is **November 3, 2014**.
- Project work according to plan. Contact your supervisors and decide on dates for supervision.
- Produce a written report (3-10 pages). Submit the report as a pdf file to all supervisors and the coordinator Deadline is **December 15, 2014**.
- Oral presentation and review of other project. Preliminary date is **December 17, 2014**.

The list of suggested projects is brief. 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. **Feature detection of hair-pin vortices**
   Modelling and understanding dynamical systems with chaotic characteristics is difficult because of their sensitivity to initial conditions and round-off errors. Some global characteristics, such as the size, duration and frequency of vortices, seem to be more stable. In this project the aim is to use feature detection to extract such characteristics from simulations in order to improve the modelling.
   Contact: KÅ, AS

3. **Bag-of-words**
   Bag of words is a popular technique within text understanding. Similar techniques have lately been tried to recognize objects in cluttered scenes. The goal of the project is to learn more about these techniques and to develop recognition algorithms based on such methods.
   Contact: JES, FJ.

4. **Tracking multiple objects using multiple cameras**
   To automatically explain what's going on in a scene by extracting trajectories of everyting 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.

5. **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.

6. **Modeling of Behavioral Data for Providing Product Recommendations in Internet Services**
   The Latent Semantic Analysis is a probability based method for modeling the behaviors in the situation where a set of users can make choices between a set of items, such as media or products in an internet service. Adequate modeling can be used as a basis for providing recommendations of items to users, and is thus integrally connected with the user experience that an internet service provides. The aim of this project is to study the expectation-maximization method for providing parameters for a Latent Semantic Analysis model. Viewed the scope of the project, we will do this by generating a dense synthetic data set consistent with the Latent Semantic Analysis model, and subsequently verify the performance of the parameters found by the expectation-maximization method on this synthetic data set.
   Contact: SVA

7. **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. (Their are other interesting tracking tasks as well.)
   Contact: TP.

8. **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.

9. **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.

10. **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.

11. **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.

12. **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.

13. **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.

14. **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

15. **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 Arrhenious 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.

16. **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.

17. **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.

18. **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.

19. **Stereo from panoramas**
Using two (spherical) panoramas taken with a baseline displacement it is possible to recover depth all around. In this project you will work on recovering 3D from such panorama pairs.
Contact: JES.

20. **Eulerian video magnification**
Recent research in amplifying small variations in video have shown that you can measure and amplify differences from tiny variations in video frames. From this you can record things like pulse, breathing etc. In this project you will use available source code to build an Eulerian magnification for a problem of your choice. (url: `http://people.csail.mit.edu/mrub/vidmag/`)
Contact: JES.

21. **Image retrieval and SIFT**
One of the most popular descriptors for image patches is SIFT. By storing a (large) collections of SIFT features and the corresponding images in a database, one obtains a simple, yet powerful image retrieval system (IMAGE GOOGLE). At runtime, the retrieval system works as follows. For an input (or query) image, SIFT feature vectors are first extracted and then, for each such feature vector, the closest SIFT vector is retrieved from the database. Database images with many similar SIFT features in common with the input image are given as output. The main problem is that each SIFT vector has dimension 128, and one needs a quick way of retrieving the nearest vector for each query vector. The aim of this project is to study such techniques for fast querying and to do an implementation. Other components like SIFT feature extraction is already available.
Contact: JES, FJ.

22. **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.

23. **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.

24. **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.

25. **Tredimensionell rekonstruktion av tvådimensionell uppklippt sfärisk yta**
På Biologiska institutionen studeras olika typer av nerver. Detta projekt handlar om nerver i urinblåsan. Den är i det närmaste sfärisk så för att få platta preparat klipper vi upp blåsan så. Uppgiften är att finna

en lämplig metod, som från denna typ av bild, rekonstruera den ursprungliga urinblåsan i tre dimensioner.Projektet ingår i ett samarbete mellan matematiska och biologiska institutionen.
Contact: SD, AH.

26. **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.

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

Contact persons (supervisors):

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