Project 1-1: PENTOMINOES

7-10-2019 / January 2020

Courses

Introduction to Data Science and Knowledge Engineering (KEN1110)
Introduction to Computer Science 1 (KEN1120)
Discrete Mathematics (KEN1130)
Computational and Cognitive Neuroscience (KEN1210)
Introduction to Computer Science 2 (KEN1220)
Linear Algebra (KEN1410)

Pentominoes

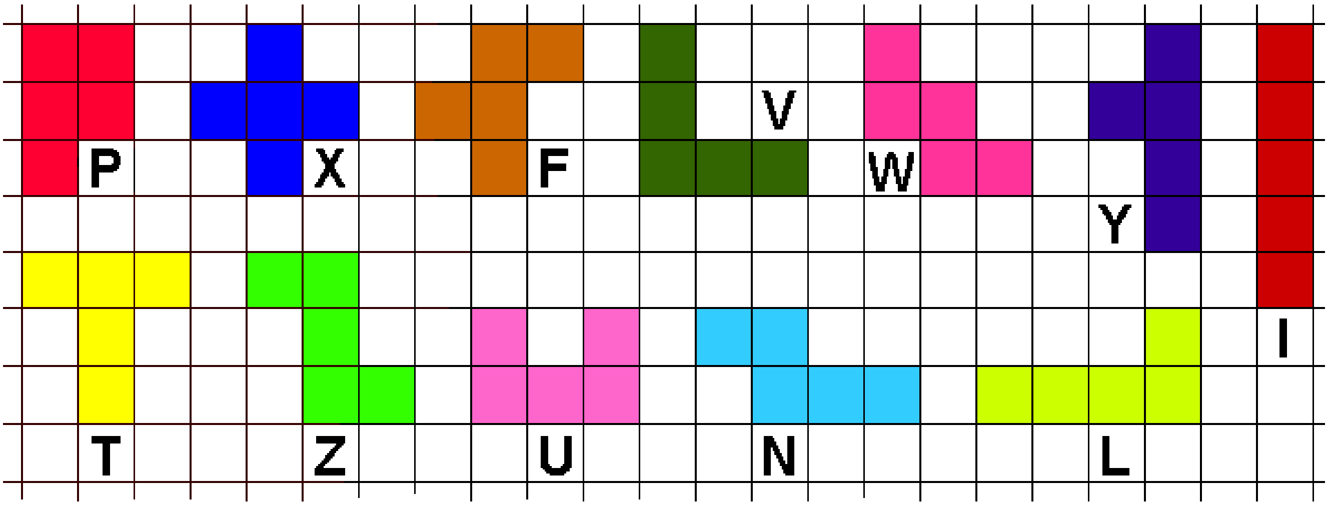
PROJECT 1-1

In this project, a (Java) computer program has to be implemented that fills up a given rectangle with given objects (pentominoes). In the second phase, a Tetris game is implemented in which the falling objects are pentominoes. In the last phase, an algorithm has to be designed to solve three dimensional knapsack problems.

Contents

1. Project description

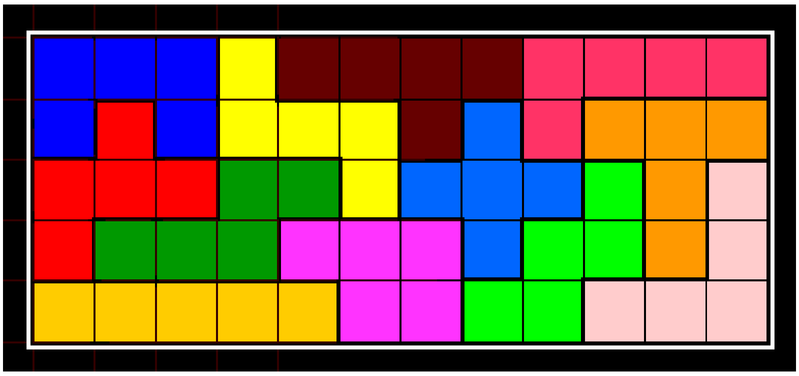
Pentominoes are the planar structures that can be obtained by attaching 5 squares of size 1x1 to each other. There are precisely 12 pentominoes and the following picture shows a representation of these.



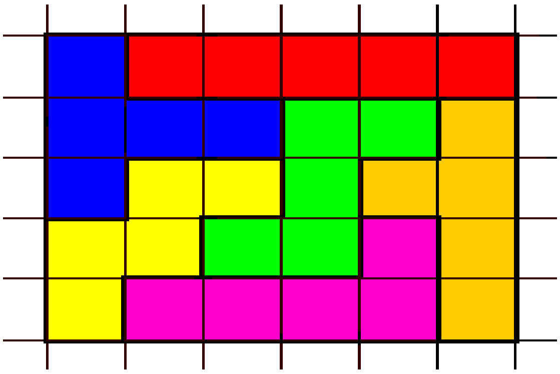
As is clear from the picture, the pentominoes can be identified by characters in a natural way.

Phase 1 (i.e. Week 6, block 1):
In Block 1.1, we want you to find out if a **given set** of pentominoes completely covers a rectangle of a **given size**. If this is possible we ask you to find (and show) one solution. Note that in a solution for a rectangle of a given size, each type of pentomino selected as input occurs at most once.

All 12 pentominoes together (i.e., input set {P, X, F, V, W, Y, T, Z, U, N, L, I}) fit in a rectangle of size 5x12. Actually, there are many ways to make them fit. The next picture shows one example how to make them fit.



To get you started, the following picture shows you one solution with half of the pentominoes (input set
{T, W, Z, L, I, Y}) on a board of size 5 by 6.



Obviously, any pentomino may be rotated or flipped over any way you like.

At the beginning of the project week (Monday October 7) we will provide you with a template code of a so-called brute force algorithm. We will provide the code via GitHub (see below for more information). Please be aware that this code is incomplete. Some parts are missing and you are expected to complete those in order to obtain a working code. Comments in the code will show which components you still need to implement.

During the project (each day at 9:00 and 13:00), we will provide you via the Student Portal with some periodic hints on how to proceed further: in particular, how to implement algorithms that run more quickly than the brute force approach. Please do not see those hints as the only way to proceed. They should help you to structure the rest of your project week. If you have not succeeded in finishing open tasks, do not feel rushed and focus on completing those before moving on to the next task. The criteria at the end of this page will show the least we expect from you in order to pass the first phase of the project.

It is very important that you test each algorithm with several inputs (i.e. different sizes of rectangles, different sets of pentominoes). The two pictures above show two examples for rectangle sizes and pentomino inputs. The code provided on the first day already gives a visualization of the pentominoes. This will help you to test your algorithms.

We want you to upload your final code for phase 1 and your final presentation to GitHub. More information on using GitHub will follow. Although you are free to use GitHub as a subversion system managing your coding, we do not expect you to use it for that purpose during the project. To upload your code, please click on the following link and follow the steps. You will need to create a GitHub login, if you do not already have one.

https://classroom.github.com/g/FjnbZ_4f

On Friday October 11, you will give a PowerPoint presentation to two examiners and a tutor. During this presentation, the examiners may ask you to demonstrate your code by running it on several different inputs (i.e. different sizes of rectangles, different sets of pentominoes) that they will specify spontaneously. For this reason, you should be able to quickly and easily run your code on different inputs (or be able to easily recompile it).

On October 11, some groups have their presentations in the morning, while others present only in the afternoon. To prevent that some groups have more preparation time than others, we ask you to upload your code and your presentation to your group repository on GitHub by October 10, 23:59. Please note that we do not expect you to work on the project until 23:59 at night – this is simply to give you maximum flexibility on how to organize your time. Late submissions will potentially have points deducted, or not be marked at all, at the discretion of the examiners.

In order to obtain at least a 6 for the first project phase, we expect you to fulfill the following requirements: you must have at least a working brute force algorithm and at least one working branching algorithm, and a structured presentation. Further improvements on the code or the implementation of additional algorithms will help increase the grade.

Phase 2:
In Block 1.2, we want you to build a computer application with a user-friendly interface to play the game of Tetris using the 12 pentomino-shapes that appear for the player in random order, each with the same probability. For the structure of the field you may use a board of width 5 and height 15.

Here is some information on the Tetris game: random pentominoes appear, one by one, at top line 15 and gradually fall down to the bottom-line 1, or to the lowest line where they are supported by (i.e. touch) other pentominoes. During its fall, a pentomino may be rotated or shifted left or right. By pushing "space bar" the pentomino drops down all the way. At the very moment a pentomino stops falling down something may happen: If, at that very moment a horizontal line of the board is completely filled with pentomino parts, then this line disappears and the remaining parts from higher lines fall down until they hit the next line. As long as these remaining parts are connected, they fall down together as one piece, and this piece is hindered in its fall as soon as one of its parts is hindered. Then it stops falling down. If all pieces are settled, a new random pentomino appears in the top line.

The player receives credits for each horizontal line they have been able to delete (to make disappear).

The application to be built keeps track of a high score list.

In addition, each project team should decide which order of the 12 different pentominoes would give the highest score if one could choose the order and if the game had only these 12 pieces falling down one by one.

Finally, you implement a bot playing the Tetris game with pentominoes. You might find it helpful to make use of the algorithms implemented in phase 1 for this part of the project.

Before December 12, 23:59, you will need to upload the final code and presentation to your group repository on GitHub. The presentation of phase 2 will take place on December 13. Schedules will be announced on the Student Portal.

Phase 3:
In Block 1.3, we want you to build a computer application with a user friendly interface that can be used for solving the so-called three dimensional knapsack problems:

Assume that your company owns trucks with a cargo-space of 16.5 m long, 2.5 m wide and 4.0 m high. Assume that your company transports parcels of three different types: A, B and C. The sizes of the types are:

A: 1.0 x 1.0 x 2.0
B: 1.0 x 1.5 x 2.0
C: 1.5 x 1.5 x 1.5

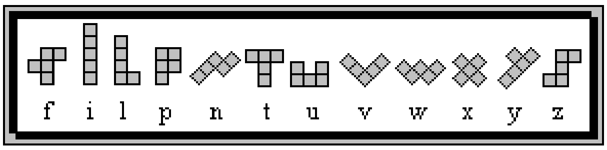
A parcel of a given type also has a certain value. Denote these values by v_A, v_B and v_C for types A, B and C respectively. Now, make a computer application that computes, for a given set of parcels (that may or may not fit into a truck), a packing that maximizes the total value.

The application does not necessarily have to find the best answer in all cases, but it should be able to find a good approximation. The application should also make a 3D-visualization of its answer – from different perspectives.

Use your application to answer the following questions:

a. Is it possible to fill the complete cargo space with A, B and/or C parcels, without having any gaps?
b. If parcels of type A, B and C represent values of 3, 4 and 5 units respectively, then what is the maximum value that you can store in your cargo-space?

Once you have answered these questions, assume that your company now transports pentomino shaped parcels of types **L, P and T**, where each of these pentominoes consists of 5 cubes of size 0.5 x 0.5 x 0.5.



Adapt your application from Phase 1 to answer the following questions:

c. Is it possible to fill the complete cargo space with L, P and/or T parcels, without having any gaps?
d. If parcels of type L, P and T represent values of 3, 4 and 5 units respectively, then what is the maximum value that you can store in your cargo-space?

In case you are wondering, all the phases of this project are motivated by “packing” problems in computer science. These are very natural problems that occur when you want to make the most economically efficient use of a given space, subject to conditions on the total size of the space, the shapes of the items you are packing, and their value. It probably won’t surprise you to learn that good algorithms for packing problems are important in, for example, shipping container loading. The knapsack problem is a typical example of a combinatorial problem. Combinatorial problems are very common in operations research, applied mathematics, and theoretical computer science. In combinatorial problems exhaustive search is generally not tractable, and heuristic solutions needs to be found (near-optimal solutions). Other common problems involving combinatorial optimization are the travelling salesman problem or the minimum spanning tree problem.

At the end of this phase, you will upload the final code, presentation and report to your group repository on GitHub. Deadlines for uploading material and schedules for the assessment moments of phase 3 will be announced on the Student Portal.

Project examiners: Pietro Bonizzi, Enrique Hortal Quesada, Steven Kelk, Siamak Mehrkanoon, Jan Niehues, Evgueni Smirnov

2. Project phases

The project assignments in block 1.1 and 1.2 are preparatory for the concluding part of project 1-1 which takes place in the third block. During week 6 of block 1.1, you will work full-time on phase 1 of the project. The project opening for this week takes place in week 5, on October 4. On Tuesday (October 8) and Thursday (October 10) of week 6, there are project meetings, which are also attended by the tutor (project coordinator).

October 11: you will give a PowerPoint presentation and a demonstration of the product. The audience consists of two of the examiners and the tutor (project coordinator). Please, also have a computer available with your code ready to be checked by the examiners during the presentation. After this demonstration, you need to prepare a short note containing the remarks of the examiners and the actions, which result from these remarks. You are requested to be present 10 minutes in advance.

The presentation takes place in three parallel sessions in rooms 0.009, 2.002 and 2.015 (BOU8-10) according to the schedule below:

	Room 0.009 (BOU 8-10)	Room 2.002 (BOU 8-10)	Room 2.015 (BOU 8-10)
09:45 - 10:00		Group 24	
10:00 - 10:15		Group 25	
10:30 - 10:45	Group 1	Group 18	
10:45 - 11:00	Group 2	Group 19	
11:00 - 11:15	Group 3	Group 20	
11:15 - 11:30	Group 4	Group 21	
11:30 - 11:45	Group 5	Group 22	
12:00 - 12:15	Group 6	Group 23	Group 12
12:15 - 12:30			Group 13
12:30 - 12:45	Group 7		Group 14
12:45 - 13:00	Group 8		Group 15
13:00 - 13:15	Group 9		Group 16
13:15 - 13:30			Group 17
13:45 - 14:00			Group 10
14:00 – 14:15			Group 11

In block 1.2, you will work minimally 4 hours a week during 7 weeks on the project. Almost every week, there is a project meeting with the tutor. At the end of block 1.2, a short presentation and demonstration is given for the examiners and tutor. Please have your computer ready for the examiners to test your Tetris game and to check your code.

Good project work in block 1.1 and 1.2 will give a head start for the concluding part of project 1-1 in block 1.3.

During the first 3 weeks of block 1.3, the students work full-time on the project. At the end of this period, each group hands in four copies of its project report to the project coordinator. At the same time, the source code, the presentation and the report are uploaded to the group repository on GitHub. Finally, a presentation of 30 minutes is given by each group. The audience consists of fellow students, the examiners, and the tutor. Please have a computer ready for the examiners to check your code.

3. Project Assessment

The phases are assessed according to the assessment forms that can be found in the appendices. The assessment form of phase 3 is still under construction and will soon be uploaded and announced via the Student Portal.

In each phase, you will be graded. As stated in the rules and regulations (see Appendix D), “the first grade is issued after the presentation first phase and accounts for 15% of the final grade. The second grade is issued after the presentation second phase and accounts for 15% of the final grade. The third grade is issued after the final assessment at the end of the third block and accounts for 70% of the grade”. More detailed information on the assessment (including individual grade reduction because of missing mandatory events) can be found in the rules and regulations.

To pass the project, you need a weighted average of the three grades higher or equal to 6. It is not required to obtain at least a six in each of the phases. A weak performance in one of the phases can potentially be compensated in another phase.

4. Project coordination

The examiners of project 1-1 are: Pietro Bonizzi, Enrique Hortal Quesada, Steven Kelk, Siamak Mehrkanoon, Jan Niehues, Evgueni Smirnov. Katharina Schüller is coordinating the project. Katharina Schüller, Chiara Sironi and Mirela Popa are tutoring the groups. Almost every week, the tutor will have a meeting with each project group. In block 1, there will be 2 project meetings during the project week.

For questions and remarks regarding the computers you can mail to lo-fhs@maastrichtuniversity.nl .

General information, information on the courses and schedules is to be found on the Student Portal:

https://eleum.maastrichtuniversity.nl.

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Appendices

A Assessment form phase 1

B Assessment form phase 2

C Assessment form phase 3

D Rules and Regulations

E Project meetings

Appendix A Assessment form phase 1

Project 1-1:
Group:
Date:

Product: poor / unsatisfactory / average / good / excellent

Are the algorithms working properly? Did the students implement multiple algorithms? Do(es) the algorithm(s) work time-efficiently? Did the students prune their algorithm(s)? Do(es) the algorithm(s) perform well with inputs from examiners?
Comments:
…………………………………………………………………………………………………

Conducted Experiments: poor / unsatisfactory / average / good / excellent

Are the conducted experiments - in order to test the correctness, efficiency and strengths and weaknesses of their algorithm(s) - reasonable? Did the students use various inputs in order to test their algorithm(s) in a proper way?
Comments:
…………………………………………………………………………………………………

Results: poor / unsatisfactory / average / good / excellent

Are the results as expected / surprising? Could the students explain them? Were the results discussed in a proper way? Did the students compare the results for different algorithms?
Comments:
…………………………………………………………………………………………………

Presentation / Demonstration: poor / unsatisfactory / average / good / excellent

Was the structure of the presentation / demonstration clear? Did the students answer the questions correctly? Were the students well-prepared (did it take a lot of time to set up the presentation / demonstration, was the order of speakers assigned in advance, …)?
Comments:
…………………………………………………………………………………………………

Group collaboration: poor / unsatisfactory / average / good / excellent

How was the collaboration in the group? Were the students prepared in the project meetings (assigning roles, agenda, minutes, …)?
Comments:
…………………………………………………………………………………………………

General Comments:
…………………………………………………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………

Grade phase 1:

Appendix B Assessment form phase 2

Project 1-1:
Group:
Date:

Approach of the assignment: poor / unsatisfactory / average / good / excellent

Was the approach standard / innovative? Did the students implement a single or multiple approach(es)? If multiple approaches were implemented, does this have demonstrable added value? If only a single approach was implemented, is it defendable that other approaches have not been considered?
Comments:
…………………………………………………………………………………………………

Argumentation of choices: poor / unsatisfactory / average / good / excellent

Were the choices – that had to be made to fulfil the project assignment - justified? Were they motivated by background literature / theory?
Comments:
…………………………………………………………………………………………………

Product: poor / unsatisfactory / average / good / excellent

Is the code correct and efficient? Was code developed to answer all the requirements of the phase? Is the GUI clear and understandable?

Comments:
…………………………………………………………………………………………………

Results: poor / unsatisfactory / average / good / excellent

Were the results as expected / surprising? Could the students explain them? Were the results discussed in a proper way? Where appropriate, did the students compare the results for different algorithms and with results from literature?
Comments:
…………………………………………………………………………………………………

Further planning: poor / unsatisfactory / average / good / excellent

Was the planning detailed enough and realistic? Was the future role distribution clear and satisfactory?
Comments:
…………………………………………………………………………………………………

Presentation / Demonstration: poor / unsatisfactory / average / good / excellent

Was the structure of the presentation / demonstration clear? Did the students answer the questions correctly? Were the students well-prepared? Did the students follow elementary guidelines for presentations (voice, eye-contact, properly designed slides, …)?
Comments:
…………………………………………………………………………………………………

Group collaboration: poor / unsatisfactory / average / good / excellent

How was the collaboration in the group? Were the students prepared in the project meetings (assigning roles, agenda, minutes, …)? Did they divide tasks such that every group member could participate in the group work?
Comments:
……

General Comments:
……
……
……

Grade phase 2:

Appendix C Assessment form phase 3

The assessment form for phase 3 will soon be uploaded to the Student Portal.

Appendix D Rules and Regulations

A complete version of the rules and regulations of the Department of Data Science and Knowledge Engineering can be found on the Student Portal.

Project regulations

Project regulations for the Bachelor's programme in Data Science & Knowledge Engineering of the Department of Data Science and Knowledge Engineering in the Faculty of Science and Engineering at Maastricht University, approved by the Board of Examiners.

Article 1 Applicability of the rules and regulations

These rules and regulations apply to the projects of the Bachelor's programme in Data Science & Knowledge Engineering, as further defined in the Education and Examination Regulations, hereinafter referred to as EER. These rules and regulations apply only for a project, not for group assignments within a course.

Article 2 Definitions

The definitions stated in Article 1.2 of the EER apply. In addition, the following definitions apply:

- *project examiner(s):* the person(s) who sets the requirements for the different aspects of the project, awards the results within the legal framework, and provides content-based supervision during the projects;
- *project:* an education component where students work in small groups on complex and challenging assignments in order to develop a variety of skills. A project spreads out over one semester (or multiple blocks). They are usually group projects, but individual projects may also occur.
- *project group:* a small group of students that jointly work on a project. Project groups can also consist of a single member.
- *project coordinator:* the person responsible for the daily management of a project semester as a whole;
- *project tutor:* the person responsible for the daily management of a project group in a certain semester or certain block during a semester;
- *project manual:* study resource for the project. The project manual contains the project assignment.
- *project meeting:* scheduled meeting between the project tutor and the project group
- *skills training:* skills training that is part of the project as referred to as "project skill" in the EER

Article 3 Organization

1. The project coordinator is responsible for the daily management of the project; regularly communicates and consults the project examiners; is responsible for the attendance registration for the compulsory project meetings (which are indicated in the project manual or in these regulations); and distributes information at the start of the project.
2. The project tutor(s) supervise the students using a process-based approach and, if necessary and expertise permitting, also a content-based approach. Students

regularly report back to the project tutors during the project meetings. The project tutor(s) track the attendance and participation of students during project meetings.

3. The project coordinator manages the project tutor(s), administers assessment, ensures that the students are given feedback and coordinates with the project examiners the composition of the project manual. The project coordinator can be a project tutor.
4. Projects are group work and all students are expected to actively participate. Students whose behaviour is still detrimental after receiving a formal warning can be expelled from the project and receive an NG. They are not allowed to take a project resit.

Article 4 Attendance and participation

Attendance and participation in the project meetings and project skills trainings, is mandatory. Missing a meeting/training in this article means failure to be present, inadequate participation or failure to make assignments.
One project meeting may be missed each block of the three blocks of a semester, without consequences. If two project meetings in a block are missed, 0.5 points will be subtracted from the final grade. If three or more meetings are missed in a block, an NG will be awarded, and the student will fail the project and will be ineligible for a resit and will have to retake the project in the next academic year. If one skills training is missed, 0.5 point will be subtracted from the final grade, if two trainings are missed, 1.0 point will be subtracted from the final grade. If three or more trainings are missed, an NG will be awarded, and the student will fail the project and will be ineligible for a resit and will have to retake the project in the next academic year.

Article 5 Examiners

The Board of Examiners appoints at least two project examiners. A project examiner may coincide with the project coordinator. The project examiners determine the grade according to a pre-agreed procedure and set extra assignments when needed.

Article 6 Project grade

1. The project group is graded on three occasions by the examiners. The first grade is issued after the presentation first phase and accounts for 15% of the final grade. The second grade is issued after the presentation second phase and accounts for 15% of the final grade. The third grade is issued after the final assessment at the end of the third block and accounts for 70% of the grade.
2. As indicated in the previous paragraph, for each project there are a number of assessment moments that may include, but are not limited to: the presentation first phase, the presentation second phase, the final presentation and the product and report examination. Failure to be present at either the presentation first phase or presentation second phase has the consequence of 1.0 point being subtracted from the final grade of the student involved. Being absent at either the final project presentation or the product and report examination has the consequence of 3.0 points being subtracted from the final grade of the student involved. Being absent at two assessment moments leads to an automatic NG for the student involved for the overall project, without the possibility of a resit.

3. The final assessment will be determined at the end of each project. Each project will be assessed separately and will be based on the following aspects:
   a. the project report;
   b. the project product;
   c. the project presentation.
   The requirements for the project product, report and presentations are determined separately for each project and will be listed in the project manual or on the Student Portal.
4. The project grade is a group grade, which applies to all members of the group. The project examiners may deviate (positively or negatively) from the group grade and issue an individual grade for students, if participation and cooperation within a group has not been homogeneous.
5. Examiners can choose to use peer assessment for adjusting individual grades.
6. For students who have not met the project requirements by insufficient attendance or participation in project meetings, skill trainings, project presentations, the product and report assessments and any other mandatory meetings, the modification to the student's grade as indicated in Article 4 and in Article 6.2 will be applied after the individual grading of the student.

Article 7 Project results: written motivation

The project results will be motivated in writing on a form that provides an overview of the project report, product and presentations and shows to what degree the results fulfil the final requirements for the project.

Article 8 Resits

The resit method shall be determined by the examiners. Resits can be individual or on a group level, where changes will be permitted to the composition of the original project group. Students who were expelled from the project are not allowed to take the project resit. A resit opportunity will only be offered if the grade is 4.0 or more (hence an NG is ineligible for a resit). The student(s) will receive the resit assignment from the examiners within 2 working days after failing the project. This additional assignment must be handed in within 15 working days.

Article 9 Hardship

The Board of Examiners can excuse students from the participation in examination/assessment moments and other mandatory meetings in individual cases due to personal circumstances, but can, in consultation with the examiners, deviate from the group grade in such cases. The Board of Examiners can also grant resits for projects in special circumstances.

Appendix E Project meetings

The aim of a project meeting is to continuously track the state of the art of the project by looking backward and forward. Appointments made are checked, new appointments are made. Moreover, the feasibility of the planning will be checked. In case of deviations, an analysis of the situation will be made in order to trace the causes. Project meetings normally are scheduled on a fixed date and time. An agenda is available on each meeting. The chairman and secretary put up the agenda. Of each meeting minutes will be taken.

The agenda below can be seen as a standard agenda. This agenda, of course, can be changed, influenced by the project or specific situation.

1. Opening
2. Announcements
   a. by the group members
   b. by the tutor
3. Incoming/outgoing post or mail
4. Minutes last meeting (mention date of meeting)
5. State of the courses
6. State of the project
   a. planning
   b. correction of the planning
   c. discussion on the log book
   d. discussion on the results of a brainstorm session or of a sub group
7. Cooperation
8. Appointments
   a. tasks to be done
   b. organization of the work
   c. chairman and secretary next meeting; monitoring the log book
9. Any other business

The project leader is chairman. He or she takes care that everybody can participate, that the atmosphere in the group is safe and open, and that conclusions are drawn and decisions are made. Summarizing is an important skill for a chairman.

The secretary takes care of the minutes. He/she sends them at last one day before the next meeting to every group member and the tutor. The minutes have to be provided with date, group number and the names of those present and absent.