Master Thesis Proposal

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September 12, 2002

1 Background

Knowing your position is, in many applications, very important. There are several ways of solving this problem. INS[1] and GPS[2] are two different types of navigation systems which can tell the position of the user. The two systems both have weaknesses, e.g. GPS has a relatively low update frequency and INS has a time-growing error. If the two systems are integrated their complementary properties can give a better performance.

There are two ways of combining the INS and GPS data. The first way is to do a decentralized integration where the GPS and INS data are processed separately. The GPS position is only used as a supporting system to estimate the drift in the INS position. The second way is to do a centralized integration. Here all the raw data from the GPS are used in the integration.

The first solution is easier to implement but is a sub-optimal solution since not all available data is used. The second solution uses all GPS data for estimating the INS error. It is also possible to use the GPS data even with less then four satellites available. In the first solution signals from four satellites are required to calculate a position in the GPS.

One drawback with using GPS is that it is very sensitive to jamming, due to the large distances to the satellites. An effective way to improve the robustness against jammers is to use a adaptive directional antenna for the GPS. The satellite positions are known so the antenna gain can, in some way, be maximized in these directions.

2 Problem definition

In this master thesis project a tightly coupled Kalman filter, that uses centralized integration between GPS and INS data, will be implemented. This filter will use both raw GPS data (pseudo-range and phase information) and information from an INS (gyros an accelerometers). The algorithms should be expressed in an Earth Centered Earth Fixed (ECEF) coordinate system.

[1] Inertial Navigation System
[2] Global Positioning System

The simulation environment should also include the possibility to arrange different combinations of jammers and to change type of antenna for the GPS. The performance will be investigated for the case with an omni-directional antenna and an adaptive antenna. The gain for adaptive antenna will be optimized for two situations, only satellite positions known and both satellite and jammer positions known.

3 Method

The raw GPS and INS data will be integrated using a tightly coupled Kalman filter. A theoretical model for the relation between the states used in the filter and the observable variables will be made.

To simulate a GPS receiver satellite orbits must be calculated. Several errors terms occur, both in the GPS and in the INS. E.g. the ionosphere introduces a unknown delay to the clock signal from the satellites. The errors that are possible (and worth) to estimate and compensate for will be carefully chosen.

The Adaptive antenna will mainly be tested in a simulation environment developed by FOI. The Electronic warfare department at FOI in Linköping will be contacted for guidance in this area.

4 Organization

The Master thesis is performed at the Swedish Defense Research Agency (FOI). The supervisor at the agency is Bengt Boberg. Examinator and supervisor at the S3 department at KTH is Ph.D. Magnus Jansson.

4.1 Contact information

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5 Project planning

The thesis project has been separated into four sub-projects (see Gantt scheme, appendix B). The sub-projects are *Planning & documentation*, *INS/GPS integration*, *Adaptive antenna simulation* and *Examination*. Each subproject has milestones and/or tollgates (see also Timeplan, appendix C).

The INS/GPS integration is common with another Master thesis performed at FOI. The work with these parts will therefore partly be done together.

5.1 Milestones

Several milestones are connected to the project. Milestones are points in time when a certain result should be achieved. Putting in milestones makes it possible to see if the project advances as planned.

	Output Document	Week
1	Master thesis proposal	37
2	Theoretical filter model	39
3	Simulation report, INS/GPS	43
4	Adaptive antennas for GPS	46
5	Simulation report, Adaptive antenna	50
6	Draft of Final report	51
7	Final report	2

5.2 Tollgates

	Tollgate	Week
1	Status report 1	38
2	Status report 2	43
3	Status report 3	48
4	Opposition	46-49
5	Oral Presentation	2-3

6 Reporting

The progress of the project will be reported in *Status reports* with regular intervals (see 5.2 Tollgates). The status reports describe the current status of the project.

A final report will summarize the performance and result of the project. It will be written in English and typeset using LaTeX.

A first coarse draft of the content in the Final report is found in appendix A.

All documentation connected to the project (e.g. Status reports and time plans) will be published on the web address `http://www.e.kth.se/~e98_jom/master_thesis/`.

A Skeleton for Final report

Introduction
– Background
— INS
— GPS
– Object
Problem definition
– Specification
Methods
– Theoretical model
Implementation
–Integration of GPS/INS
–Adaptive antenna
Results
– Simulation results
Conclusions
– Future work
References
Appendix

B Gantt

Gantt chart

Master Thesis in Signal Processing at the Swedish Defence Research Agency (FOI)

Updated 2002-09-12

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Activity			September				October					November				December				January			
		35	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**1**	**2**	**3**	**4**
Planning & documentation																							
Project planning		5		20																			
Status reporting							5				5				5								
Total time	40																						
INS/GPS integration																							
Literature studies		30		15	10	10	10																
Satellite empherisis generation				5	10																		
Theoretical filter model					20	15																	
Filter implementation						15	30	35	24														
Matlab documentation									10														
Simulation										20													
Evaluation										10													
Total time	239																						
Adaptive antenna simulation																							
Investigation/Literature studies				2					5	10	35	30											
Visit FOI Linköping													40										
Implementing matlab toolbox											5	5		30	20	16	3						
Toolbox documentation																2	5						
Simulation																	20						
Evaluation																	5	10					
Total time	243																						
Examination																							
Preparation for Opposition													5	5									
Opposition																2							
Prepare Presentation																				15	10		
Oral presentation																						2	
Final report				1				10	8			10	5	10	20	20	10	30		25	20		
Total time	208																						
Number of hours		35	0	43	40	40	45	45	47	40	45	45	50	45	45	40	43	40	0	40	30	2	0
Total number of hours																							**760**

C Time plan

Time plan

Master thesis project 2002

Updated 2002-09-12

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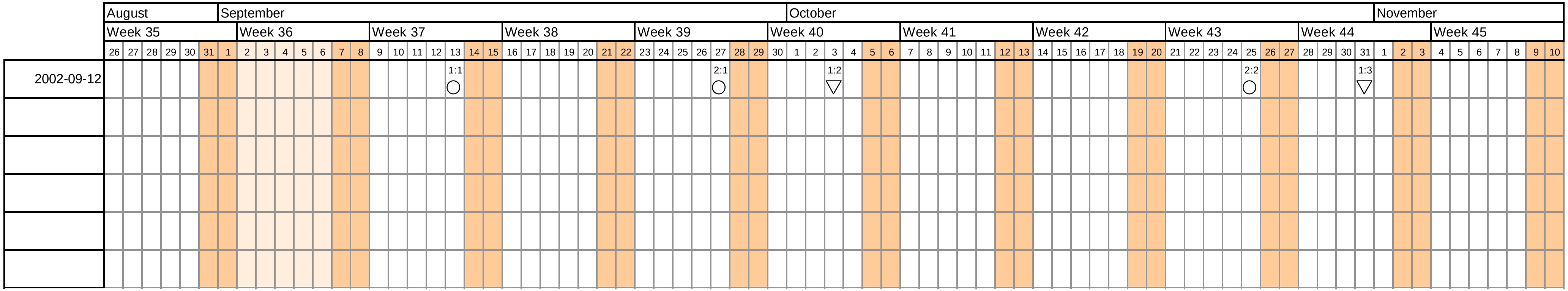

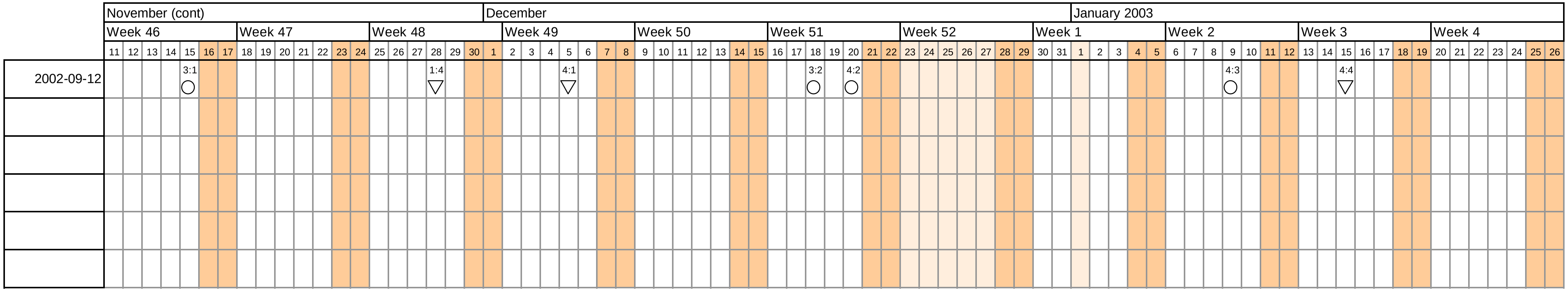

○ Milestone

▽ Tollgate

Planning & documentation

- ○ 1:1 Master Thesis proposal
- ▽ 1:2 Status report 1
- ▽ 1:3 Status report 2
- ▽ 1:4 Status report 3

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INS/GPS integration

- ○ 2:1 Theoretical filter model
- ○ 2:2 Simulation report, INS/GPS

Adaptive antenna simulation

- ○ 3:1 Description of adaptive antennas
- ○ 3:2 Simulation report, Adaptive antennas

Examination

- ▽ 4:1 Opposition
- ○ 4:2 Draft of Final report
- ○ 4:3 Final report
- ▽ 4:4 Oral presentation