MŰEGYETEM 1782

Budapesti Műszaki és Gazdaságtudomái Egyetem
Villamosmérnöki és Informatikai Kar
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Autonóm oceanográf

Diplomaterv

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Kivonat

Jelen dokumentum egy diplomaterv sablon, amely formai keretet ad a BME Villamosmérnöki és Informatikai Karán végző hallgatók által elkészítendő szakdolgozatnak és diplomatervnek. A sablon használata opcionális. Ez a sablon LaTeX alapú, a *TeXLive* TeX-implementációval és a PDF-LaTeX fordítóval működőképes.

Abstract

This document is a LaTeX-based skeleton for BSc/MSc theses of students at the Electrical Engineering and Informatics Faculty, Budapest University of Technology and Economics. The usage of this skeleton is optional. It has been tested with the *TeXLive* TeX implementation, and it requires the PDF-LaTeX compiler.

Introduction

Seaborne measurements are often expensive and time consuming, though they can have a large impact on the area, where the data have been obtained. In 2011 the naval safe zone around the Fukusima accident was laid down based only on estimates of the radiation contamination[**?**], because low amount of measurement data was available due to high measurement costs and risks. Another notable example are the coastal waters of Greenland, because are very poorly mapped up to present day[**?**]. Ships have to sail in a roundabout way around the island, because the risk of wrecking in unknown fjordic area is very high. This is a huge waste of time and natural resources annually.

Oceanography and Bathymetry

Not many people come across these expressions often. Oceanography can be summarized as a branch of Earth science that studies the ocean. It includes a wide range of topics, like the study of marine ecosystem, ocean currents, plate tectonics and the geology of the sea floor. Bathymetry is the study of underwater depth of lake or ocean floors. The advancing technology allows even more possibilities, like the aforementioned radiological measurements, or general monitoring of the seas.

Advantages of autonomous vessels

Oceanographic measurements today are carried out by large crewed ships, but in many cases they could be replaced by a number of smaller crafts, in order to reduce surveying time and cost and increase the available manpower in other tasks. These vessels could have the ability to sail previously unsurveyable areas as well, thanks to the shallower draught and smaller size.

Limitations

The most notable limitation of the current mobile robotic technologies are their small size itself. It means the relatively small range based on their smaller power capabilities, and narrow field of application.

The aim of this project is to develop an autonomous surface vehicle, which is capable of conducting multiple seaborne measurements. To execute an oceanography mission, the ship must be capable of autonomus navigation based on Global Positioning System (GPS) and an Internal Measurement Unit (IMU), to further enhance the precision in hazardous environment.

Figure 1: *The AAUSHIP prototype on her maiden voyage*

Development guidelines

In order to keep a sensible and extendable system, the control software of the ship follows the guidelines of the Model-Based Design approach. The system software can be divided to two different kind of modules, one that is dependent, and one that is independent from the physical characteristics of the vessel. In order to maximize the extendability of the system, the fix (independent) modules must be completely general, but as thorough as possible, so as to keep the complexity of the changeable (dependent) software of the robot minimal.

The environment stored in the control system must be extendable to the third dimension, and must be able to track changes over time. The tasks of the low level control must be as specific and as basic as possible. All calculations and control should be implemented in the high level controller. the high level controller must be parametrized, based on the low level and hardware characteristics.

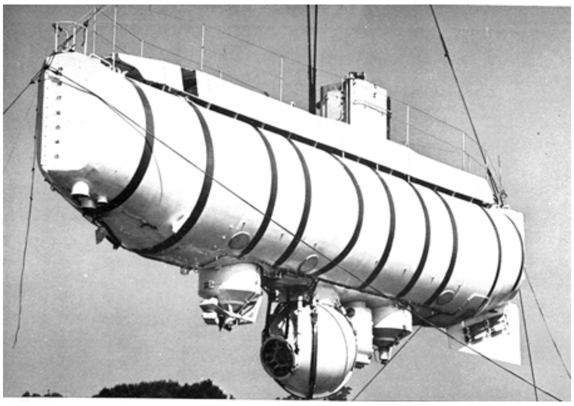

Figure 2: *Bathyscaphe Trieste, the first manned vessel that reached the bottom of Challenger Deep (Mariana Trench)[?]*

The point of these guidelines is to create a system of components with major reusability. Ideally a general Cross-platform High Level Controller controls different kind of vessels, through a standard interface. When changing to an arbitrary different vehicle, only the Low Level Controller must be replaced, which stores the characteristics of the vessel and implements the actuator control.

Operation models

A typical oceanography application starts on the shore. A science team analyzes the currently available data, then marks the area of measurements on the map. The map data is transformed to a measurement path by the scientists or by the automatic waypoint planner of the ship. The autonomous surface vehicle is then outfitted with the right sensors for the task, and a manned ship transports it close to its destination. The crew can set the research vessel to manual, automatic or fully autonomous mode.

Manual control In this mode it's possible for the operator to control the movement of the ship, degree of freedom-wise or control the actuators themselves. The primary intent of this mode is for testing or malfunction-recovery.

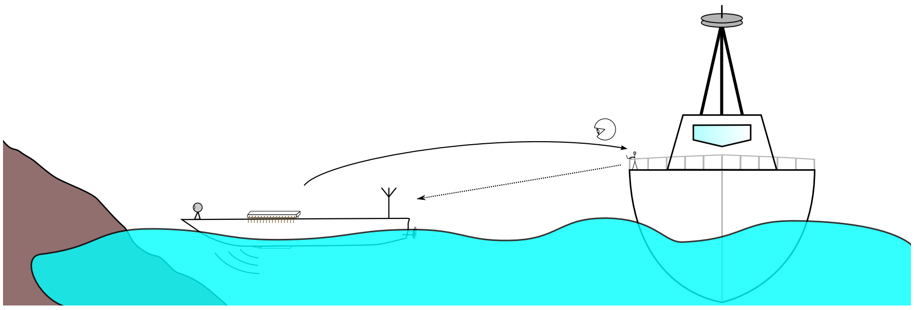

Figure 3: *Manual remote control*

Automatic control In automatic mode the "brains", remain on the crewed vessel, and the research craft remains in wireless connection with the Mothership. When the measurements are complete, the oceanographer returns to the mothership. In automatic mode it is always possible to switch to manual control and back, or update the measurement path, etc.

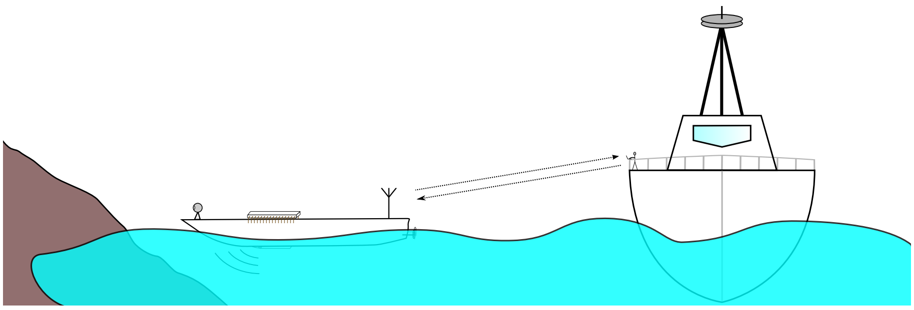

Figure 4: *Automatic supervised control*

Autonomus control In Autonomus mode the ship carries everything that is needed to complete the task. Connection to the mothership can be cut, and the vessel carries the orders out autonomusly. Intervention in this mode is only possible until the oceanographer is in range of the mothership.

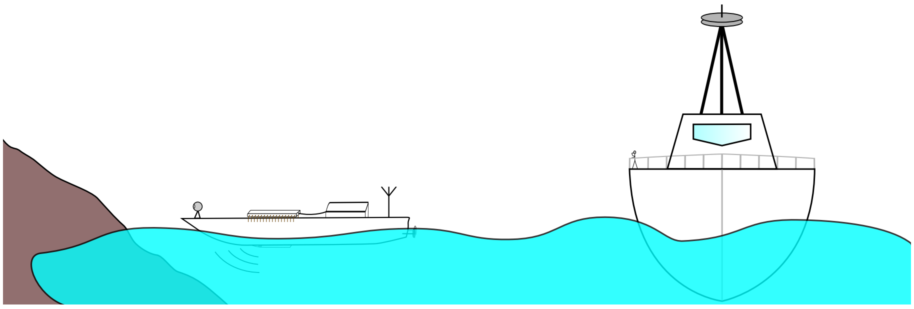

Figure 5: *Autonomus control*

Squadron mode In case there are multiple research vessels, they can form a squadron. In this setup only one of the ships needs to be in range of the crewed mothership. Alternatively one autonomus ship is capable of controlling multiple automatic crafts, taking over the role of the mothership.

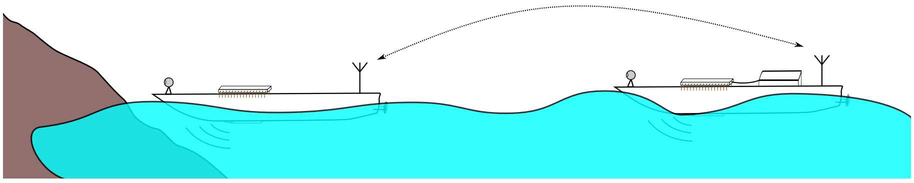

Figure 6: *Squadron mode*

Code: Main.py
https://www.dropbox.com/s/h1067ywmdajkegk/Main.py

The mission planning steps are implemented in Main.py, which is the main part of the program, responsible for initializing the system, setting the target area, mode of routing, navigation, etc. Later Main.py will provide a Graphical User Interface as well.

Operational Requirements

General requirements of autonomus vehicles

Requirements of survey ships

Combined requirements

In order to execute a rational oceanography task, a number of valid objectives must be set. These objectives are usually one or more of the following[**?**]:

- A set of geographical measurement locations, with or without time and measurement type conditions
- A certain area of interest
- Maximal action duration requirement
- Other

The task planning is usually carried out by the scientist group, but some auto-planning modes need to be supported. A typical task is the creation of a measurement-grid, with preset definition, in a certain geographical area. The High Level Controller (HLC) uses a Mission planning time algorithm, to support the auto-generation of the waypoints. This module is the "Waypoint planner", which outputs a list of coordinates that contains the measurement points.

Once the ship reaches the current waypoint, it determines the next aim.

A set of points defining a path can be specified for the ship, but it does not ensure that the created path is valid, therefore a second "Pathplanning" stage is required, which analyzes the generated set of locations and creates a path that is actually sailable by the ship.

Common ship body and propulsion types

Hull types

Propulsion types

Considerations

Dynamic models of ships

Different effects

Building simulation environment

Uncontrolled system simulation results

Control system design

Requirements of control

Controllers for deterministic systems

Roboust controllers

Model predictive control

Logical system

Concept of separation

System design

physical layout

GPS Acquisition

Bluetooth connectivity

Sensors and effectors

Hardware design

Remote control

Hardware

Assembly

Pathplanning

Waypoint planning

Waypoint ordering

Comparsion of methods (length/WP)

Map reading

Swarm intelligence

Dynamic pathplanning, time-scaling

Cooperative strategies

Formations

Measurements and results

Conclusion

This document is meant to succeeds my previous work[**?**]. Several major functionalities have been added, and the engine behind under the hood has been changed, and will keep changing.

My most important observation during the Project Laboratory I. was that the perceived significance of the system components might differ from the reality. The successful implementation of the different pathplanning systems and navigation required a very solid and relatively simple Map object, that can be relied on.

With the major components of the HLC now complete, up and running, it's possible to move to the next phase. In Project Laboratory II. the LLC will be designed, the communication protocol between the objects and the ship itself, in order to accomplish a more-or-less working prototype by the end of 2013.

Acknowledgment

Ez nem kötelező, akár törölhető is. Ha a szerző szükségét érzi, itt lehet köszönetet nyilvánítani azoknak, akik hozzájárultak munkájukkal ahhoz, hogy a hallgató a szakdolgozatban vagy diplomamunkában leírt feladatokat sikeresen elvégezze. A konzulensnek való köszönetnyilvánítás sem kötelező, a konzulensnek hivatalosan is dolga, hogy a hallgatót konzultálja.

Appendices

A TeXnicCenter felülete

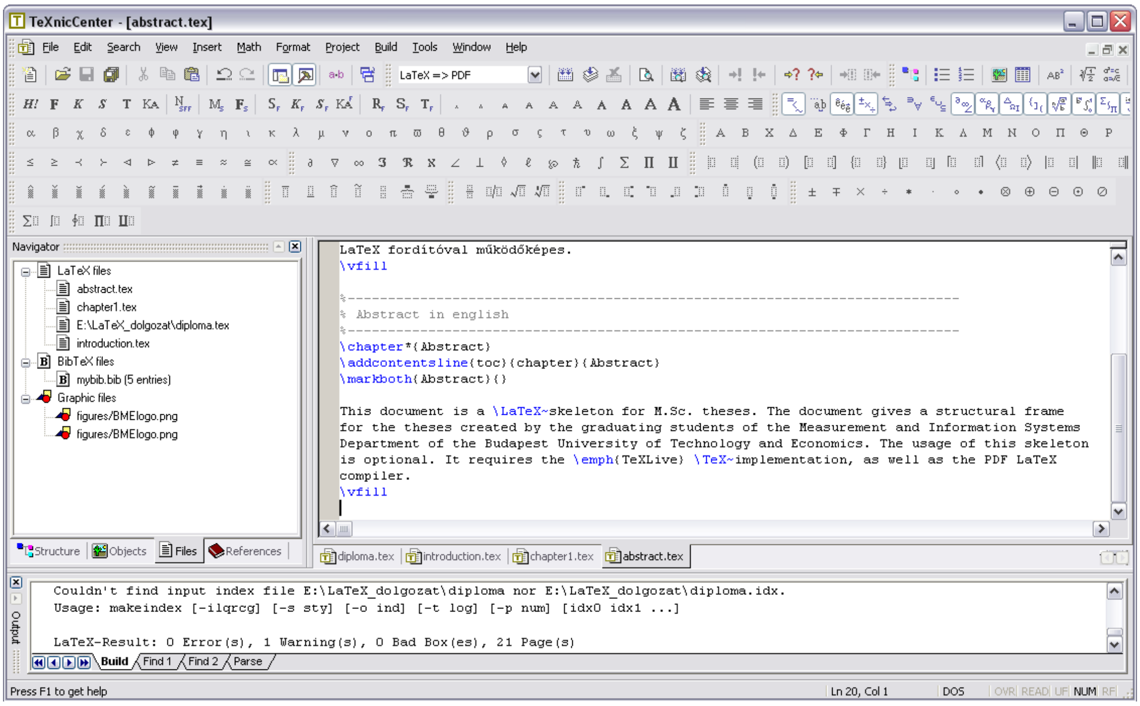

Figure F.0.7: *A TeXnicCenter Windows alapú LaTeX-szerkesztő.*

Válasz az „Élet, a világmindenség, meg minden” kérdésére

A Pitagorasz-tételből levezetve

$$c^2 = a^2 + b^2 = 42. \tag{F.0.1}$$

A Faraday-indukciós törvényből levezetve

$$\mathrm{rot}\, E = -\frac{dB}{dt} \qquad \longrightarrow \qquad U_i = \oint_{\mathbf{L}} \mathbf{Edl} = -\frac{d}{dt}\int_A \mathbf{Bda} = 42. \tag{F.0.2}$$