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# "easyMine" – realistic and systematic mine detection simulation tool

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**Abstract.** Mine detection is to date mainly performed with metal detectors, although new methods for UXO detection are explored worldwide. The main problem for the mine detection to date is, that there exist some ideas of which sensor combinations could yield a high score, but until now there is no systematic analysis of mine detection methods together with realistic environmental conditions to conclude on a physically and technically optimized sensor combination. This gap will be removed by a project "easyMine" (Realistic and systematic Mine Detection Simulation Tool) which will result in a simulation tool for optimizing land mine detection in a realistic mine field. The project idea for this software tool is presented, that will simulate the closed chain of mine detection, including the mine in its natural environment, the sensor, the evaluation and application of the measurements by an user. The tool will be modularly designed. Each chain link will be an independent, exchangeable sub- module and will describe a stand alone part of the whole mine detection procedure. The advantage of the tool will be the evaluation of very different kinds of sensor combinations in relation of their real potential for mine detection. Three detection methods (metal detector, GPR and imaging IR-radiometry) will be explained to be introduced into the easyMine software tool in a first step. An actual example for land mine detection problem will be presented and approaches for solutions with easyMine will be shown.

## 1 Introduction

Mines would pose such a humanitarian disaster if they could be detected and removed with the same speed as they are buried. Currently are over 120 million land mines buried in 55 countries and another 90 million mines in stock (Landmine 2003). There are over 700 different types of land mines - from the simple, pressure activated mines to those with highly sophisticated sensors (Fig. 1). Mine detection is to date mainly performed with metal detectors, prodders and dogs although new methods for UXO detection are explored worldwide. But there is obviously no systematic analysis of detection methods and especially its synergetic combination until now (GAO, 2001). There is also no consideration of realistic environmental conditions. This deficit will be removed by a project which results in a simulation tool for optimizing land mine detection in a realistic mine field.

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## 2 easyMine simulation tool

In the project a software tool will be established to simulate the closed chain of mine detection process starting with the buried mine in soil via the sensor up to the interpretation and application of the "measurements" by an user as a basis for the interdisciplinary concentration of specific knowledge for a systematic analysis of land mine detection processes in a near realistic environment including socioeconomic embedding.

The tool is modularly designed. Each chain link is an independent, exchangeable submodule. Each module describes a stand alone part of the whole mine detection procedure (Fig. 2).

The first module characterizes the mine together with its environment (module "Model Mine in/on Soil" in the scheme). It is planned to model the physical, chemical and geometrical entirety by 3D elements (e.g. using the Finite Element Method). An additional approach will be to create a number of models which are especially designed for the different detection methods and sensor types, respectively.

Interfaces to data bases are necessary for both approaches ("Mine Data Base", "Environmental Data Base"). The databases contain available information about the mines (shape, mass, metal content and other) and the information about the environment of the buried mine (kind of soil, humidity, surface properties). Additionally, the module "Model Mine in/on Soil" has an user access to specify the depth the

**Fig. 1.** Antipersonal mines found in Croatia: top down: PMA-2, PMA-1A, PMA-3

mine is buried or the current weather conditions (snow, rain, temperature as function of the day time).

The following module defines the detection methods and their processing order ("Detection Method Selection").

The module "Model Specification and Simulation" simulates the signal transfer between the specified mine-soil model and the sensor. It converts the signal to measurable quantities. It contains both the physical or chemical model of the mine in soil and for example the radiation transport from the soil surface to the sensor, which may be air borne (airplane ; airship). Available scientific and commercial software has to be implemented into this module.

The module "Sensor Carrier Influence" takes into account disturbances by stochastic displacements of the sensor (lurching of airplane, jolt by car).

The module "Sensor Transfer Function" simulates the signal conversion by the senor (grey scale image, acoustic signal of the metal detector, barking of the sniffer dog. The module can contain both a perfect simulation of all sensor details and also a simplified transfer function, for instance a transition matrix.

In the module Sensor Signal Processing, the sensor output is converted into a user friendly presentation of the measurement results (e.g. false colour representation) by using an evaluation algorithm.

By the following module "Processing Result Assessment" a decision will be made about the existence of a mine. In the most simple case the user decides, based on the results from the module above. In advanced versions the decision could be made by a smart discriminator algorithm.

The interfaces between the modules allow the (dynamic) substitution of the whole module content without modifications of the other modules. That means, if for example a mine with another shape or in another environment (more wet instead of dry soil) should be found, only in the first module has to be considered. Further applications are optimization of sensor design by the variation of sensor parameters or testing several evaluation algorithms.

## 3 Advantages and application

The origin of the project idea and the advantage of the tool is the evaluation of very different kinds of sensor combinations in relation of their real potential for mine detection. The main problem for the mine detection to date is – that there exist some ideas of which sensor combinations could yield a high score, but until now there is no systematic analysis of mine detection methods together with realistic environmental conditions to conclude on a physically and technically optimized sensor combination (Bach, 2003). One reason seems to be the immense expenses of such an analysis based on hardware sensor development. The software simulation tool would fill exactly this gap.

Another important advantage of the tool is, that it can become a part of more general models, that consider for example reliability criterions or socio-economic approaches. So it can also become an indispensable instrument for strategic decision-making and decision-planning in the research-political and economical field.

About 20 very different methods for the mine detection are known at present. The innovation content and the attractiveness of the formulation consist in the flexible modular design of the simulation tool. This design enables the implementation of all, also those detection methods coming along in the future.

The sensitivity limits of the different detection methods can be determined by the simulated but realistic variation of the parameters of the model "Mine in soil" (variation of mine types, variation of soil consistency and surface properties and

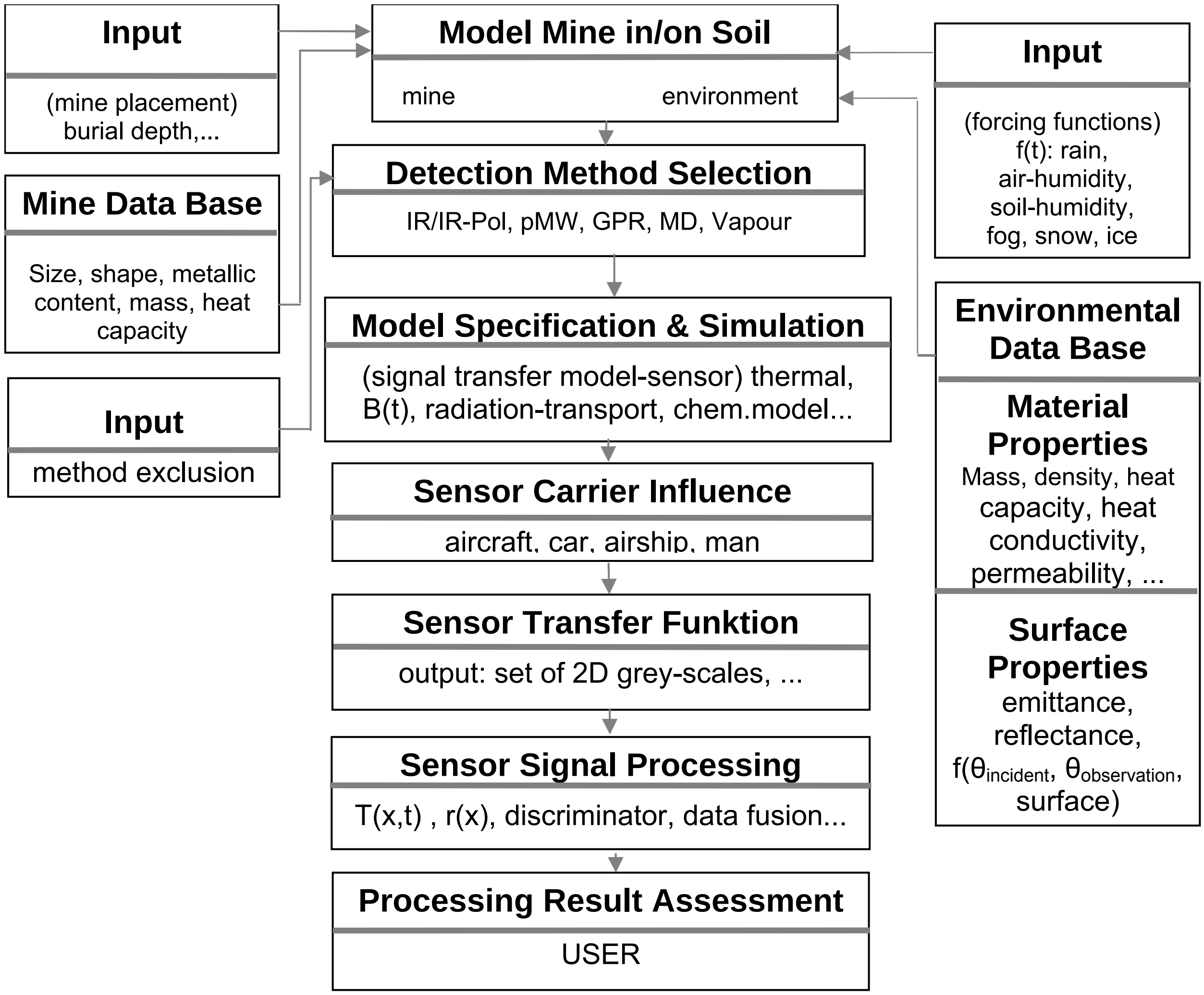


**Fig. 2.** Modular structure of the "easyMine" simulation tool.

variation of weather situation). This will give comparable reliable results for the different detection methods. For this case the tool provides the possibility to find out the optimal method (e.g. the most reasonable) adapted to the situation. A further advantage of the tool is also to check the detection reliability of the combination of methods being near by the sensitivity limit and merging their measurements.

The applications of the tool range from its implementation in more general studies like socio-economic interactions of demining, up to the decision support of the detection method selection in the concrete mine field.

Up to now a systematic analysis and the comparison of the very different detection methods and the possibility of a realistic simulation of the mine in soil up to the evaluation of sensor output is not available. The creation of the software tool is an important step to an overdue comprehensive approach to the problems of land mine detection. The availability of the tool is an essential contribution to systematization, efficiency and reducing of costs. It will save human life.

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