JSMAA: an open source software for SMAA computations

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ABSTRACT. Most software for Multiple Criteria Decision Analysis (MCDA) implement a small set of compatible methods in a closed monolithic software. Sometimes, however, the model can be generated through external information sources and therefore the supporting software should enable their integration. This paper motivates the need for model generation through existing applications of Stochastic Multicriteria Acceptability Analysis (SMAA) methods, and describes the JSMAA software that implements the SMAA-2, SMAA-O, and SMAA-TRI methods. JSMAA is open source and divided into separate graphical user interface and library components, enabling its use in systems with a model generation subsystem.

KEYWORDS. Stochastic Multicriteria Acceptability Analysis (SMAA); Open Source Software; Model Generation; JSMAA

1 INTRODUCTION

Multiple Criteria Decision Analysis/Aiding (MCDA, also referred to as -Making, MCDM) is a subfield of operations research for tackling managerial decision problems in which several decision alternatives are evaluated in terms of multiple criteria. The evaluation is done in order to either choose the best/small subset of alternatives, to rank them, or to sort them into ordered categories (Roy, 1996). Although the amount of published MCDA applications has increased substantially in the past 15 years (Wallenius et al., 2008), the impact of decision support systems (including implementation of MCDA) in managerial practice has not (Keen and Sol, 2008). There are various possible reasons for the lack of impact, including the following:

1. The scientific MCDA community has produced a vast amount of *useful* methods, but a majority of them aren't supported by *usable* software (for definitions of the terms *useful*, *usable*, and *used*, see Keen and Sol, 2008). Most of the MCDA software implements a single method or a small set of similar methods (French and Xu, 2005; Belton and Hodgkin, 1999). The software is often developed in an academic environment, is closed source, and requires a license for full use (Weistroffer et al., 2005). So, the licensing model is often commercial, but the development status "experimental" and features provided by the software limited.

2. The reported real-life *use* of MCDA methods appears mainly in disciplines where models can be constructed and calculated manually or with a general purpose software, e.g. in location (cf. Nickel et al., 2005) or in financial decision making (cf. Spronk et al., 2005). The limited practical application of MCDA in new disciplines can be due to difficulty of integrating existing MCDA software with rest of the decision support technology (e.g. simulation models, GIS). Even when artificial intelligence techniques are applied, the decision support system is often monolithic (Siskos and Spyridakos, 1999).

In this paper, the term *model generation* is distinguished from *model construction*. Construction is defined as a manual process, whereas generation refers to an automated one. The actual "metamodeling" defining rules governing the model generation is out of scope of this paper. Instead, this paper describes the need for MCDA software components that enable model generation, and subsequently, could lead to the useful methods being more widely used in managerial practice. The need for such components is considered in the methodological context of Stochastic Multicriteria Acceptability Analysis (SMAA).

SMAA is a family of MCDA methods for all MCDA problem statements (Tervonen and Figueira, 2008). It is based on inverse parameter space analysis through Monte Carlo simulation. The different SMAA methods allow tackling problems with uncertain, imprecise, and (partially) missing information about the preferences, the technical parameters, and the criteria measurements. In practice the SMAA methods cannot be calculated manually due to the use of simulation; a software implementation is required. This paper describes the first stable SMAA software, JSMAA, that currently implements the SMAA-2, SMAA-O, and SMAA-TRI methods. JSMAA is developed in Java and licensed under open source, and therefore can help to mitigate the problems described before by enabling model generation.

Section 2 continues by introducing the reader to the practical need for model generation with SMAA through two relevant applications. The JSMAA software is described in Section 3. Section 4 concludes with discussion of alternative ways of designing modular MCDA software.

2 APPLICATIONS OF MODEL GENERATION

In order to have the *useful* MCDA methods *used* in practice, the different *use cases* must be supported by *usable* software. The use cases and software of MCDA have previously been considered by French and Xu (2005) and Belton and Hodgkin (1999). They defined multi-criteria problems as one-off decisions where the decision making process starts with a construction of a model and terminates with an evaluation of the decision (the process can be iterative). Although one-off decision problems dominate real-life cases, the need for model generation is evident with the increasing number of decision support systems that can benefit from an MCDA module. Therefore, MCDA software should allow integration with rest of the organizational information infrastructure, as illustrated with the following two applications.

2.1 Application 1: elevator planning

Modern elevator systems in high-rise buildings consist of groups of elevators with centralized control. The goal in *elevator planning* is to configure a suitable elevator group to be built. The elevator group must satisfy specific minimum requirements for a number of standard performance criteria. In addition, it is desirable to optimize the configuration in terms of other criteria related to performance economy and service level of the elevator group.

Tervonen et al. (2008) have considered elevator planning with SMAA. The service level criteria were dependent, and the measurements defined through a multivariate normal distribution estimated with data from the KONE Building Traffic Simulator. Although the application was succesful and demonstrated the applicability of SMAA in elevator planning, the process of model building required multiple manual steps for constructing the alternatives' criteria measurements, as shown in Figure 1. The SMAA computations were done with a custom software to allow sampling from the multivariate normal distribution.

In this application, if there were at that time available open source SMAA components, the sampling matrix could have been customized and the data flow from the building simulator to distribution estimation to the SMAA model automated, e.g. in R (R Development Core Team, 2008). The JSMAA software presented later in this paper is open source, and therefore could be refactored to use a customizable sampling matrix, e.g. through inverse of control.

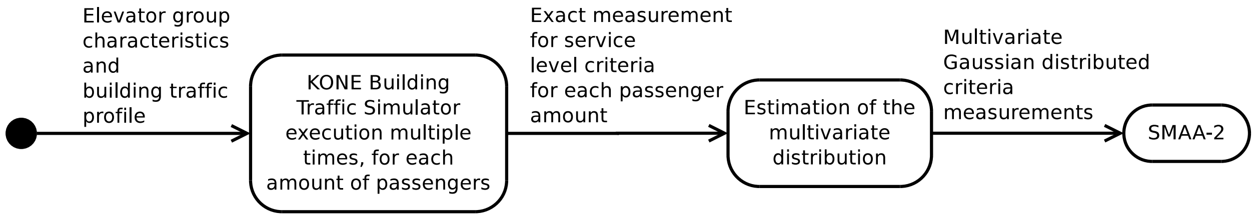

Figure 1: Construction of criteria measurements in application of SMAA-2 in elevator planning.

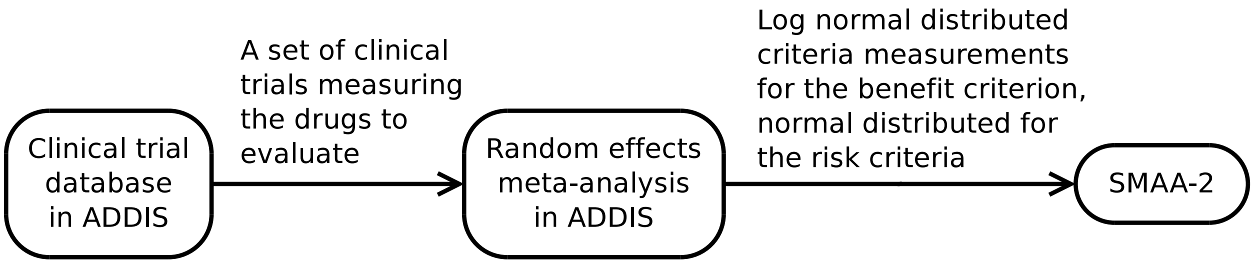

Figure 2: Generation of decision alternatives in application of SMAA-2 in drug benefit-risk analysis.

2.2 Application 2: drug benefit-risk analysis

Drug benefit-risk analysis is done daily by health care professionals, such as regulators, practicing physicians, and employees of insurance companies, to evaluate the safety and efficacy of different medical compounds. The benefit is often evaluated as the efficacy of a compound over an active comparator or placebo. The risks can be defined as increase in the amounts of adverse drug events. Tervonen et al. (2010) proposed to apply SMAA-2 in drug benefit-risk assessment. In their example application, the model was constructed for a set of second generation antidepressants. The criteria were formed from efficacy (benefit criterion) and the rates of most common adverse drug events (risk criteria). The weights were elicited in ordinal form by considering two scenarios: mild and severe depression.

Initially the criteria measurements were defined as normal distributed for the risk criteria, and log-normal for the benefit criterion, by using meta-analytical data from the literature. Afterwards, similar models could be generated with data from a clinical trial database in the ADDIS (Aggregate Data Drug Information System) software (cf. `www.drugis.org`). This data flow is presented in Figure 2. In connection with this application the JSMAA software was made more modular to allow easier integration into external systems - no scripting was needed and the integration could be done directly in Java.

3 JSMAA

JSMAA (`www.smaa.fi`) supercedes CSMAA that was developed partly to support application of SMAA-TRI (Tervonen et al., 2009a) in nanomaterial risk assessment (Tervonen et al., 2009b). The development continued to enable application of SMAA-2 in drug benefit-risk assessment as described in the previous section. Currently (as of version 0.6) JSMAA implements SMAA-TRI for stochastic sorting with ELECTRE TRI and SMAA-2 (Lahdelma and Salminen, 2001) for ranking with multi-attribute value theory. The criteria measurements can be defined as exact real values, or imprecise as intervals, as ordinal ranks, or as normal- or log-normal distributed. JSMAA supports exact, imprecise linear constrained (interval) or ordinal (SMAA-O, see Lahdelma et al., 2003) preference information (weights). In case of SMAA-TRI, the outranking criteria's preference- and

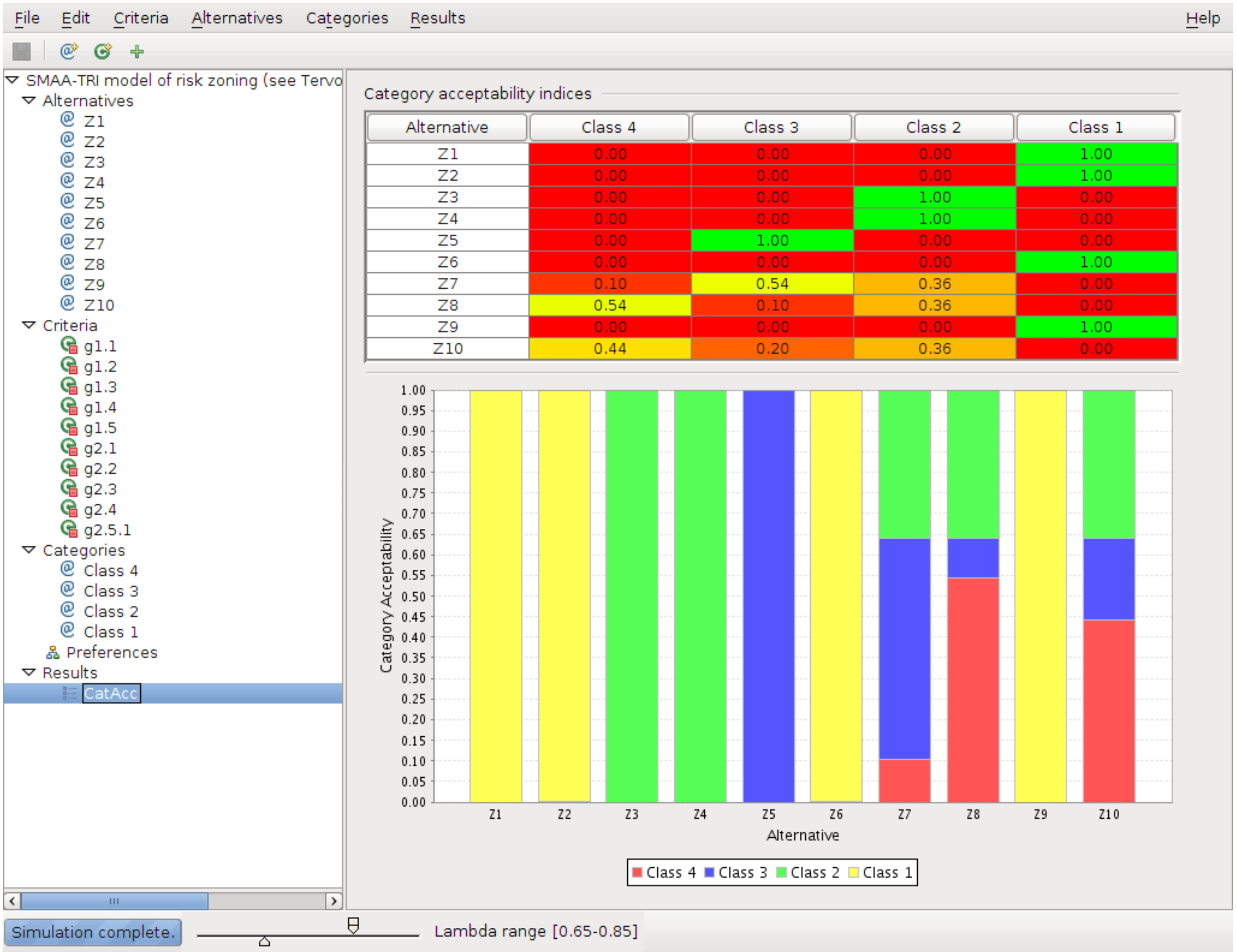

Figure 3: SMAA-TRI category acceptability indices in JSMAA v0.6.1.

indifference thresholds can be defined exact or as disjunct intervals, and the SMAA-TRI lambda cutting level as an interval. JSMAA tries to minimize the required amount of user interaction, and uses a separate thread to run the simulations in background whenever the model changes. In practice the simulation overhead is often unnoticeable to the user.

The user interface of JSMAA is divided in two. On the left side is a tree view of the model and the results. A panel on the right side of the view shows details for the model element or results that is currently selected in the left tree. Figure 3 presents the layout when the category acceptability indices of a SMAA-TRI model are selected. Note the lambda-slider in the bottom of the screen. Whereas the other parameters of the model (criteria measurements, preferences) are input in their corresponding screens, the lambda cutting level is separated to the bottom tool bar to allow easily experimenting how the results change with (imprecise) values for the technical parameter lambda.

In order to support integration with external systems, the model and the results computation are separated to an independent library (`http://github.com/tommite/jsmaa-lib`). The library supports storing and loading models in a XML format with a proprietary schema. It would be preferable to have models in XMCDA (`http://sma.uni.lu/d2cms/xmcda/`) so that they could be computed with software supporting XMCDA input. However, currently (as of 2.0.0) XMCDA doesn't support normal- or log normal distributed criteria measurements.

JSMAA is implemented in Java and therefore it is usable in all major operating systems (including Linux, Mac OS X, and Windows). Although it is currently the most mature SMAA implementation, it is far from complete, and extra effort has been made to allow new developers to continue the work. JSMAA is built with Maven 2, which makes setting up the development environment in Eclipse very easy (cf. `www.smaa.fi/jsmaa.php`). The source code is openly available in git repositories at `http://github.com/tommite/jsmaa` and `http://github.com/tommite/jsmaa-lib`.

4 CONCLUSIONS

The lack of impact of MCDA in managerial practice is partly caused by the current implementation of MCDA methods – in proprietary software that is hard to integrate to existing information systems. Open source software and model generation can enable wider application of MCDA in new fields where the decision alternatives or criteria are generated as part of the decision support process. Most of current MCDA software do not provide an interface for integration with external systems, and therefore there exists a need for design and implementation of more modular MCDA components.

Such components can be built top-down, through an implemention of a complete method and provision of an interface for the model initialization and results visualization. This paper described a software build in such a way, JSMAA, implementing the SMAA-2, SMAA-O, and SMAA-TRI methods. Another approach is to design the components bottom-up as promoted by the Decision Deck Diviz platform (`www.diviz.org`). In Diviz, small algorithmic components communicating through an XML data standard, XMCDA, are combined to form workflows that represent MCDA methods. The bottom-up approach allows for more interactive in-depth analysis of different parts of the methods, and it seems quite suitable for educational purposes. Whether it is a proper way to design components providing interface for integration in domain-specific decision support systems is questionable. However, when XMCDA matures, it could become *the* MCDA data exchange standard that would allow MCDA methods to be easily interchangeable.

The learning that the decision makers experience with multi-criteria analysis is considered by many MCDA experts as one of the major advantages of MCDA. The model construction is dependent on the method, which in turn implies how the decision makers' preference structure can and should be elicited. Care needs to be taken when MCDA components, such as the library of JSMAA, are used in domain-specific decision support systems: the method prerequisites (e.g. the meaning of weights, cf. Choo et al., 1999) need to be met. However, reasoning that only an expert is able to construct mathematically correct models should not be used as an excuse to refrain from developing usable and open MCDA software components.

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