Computers and Electronics in Agriculture 113 (2015) 174–192

Contents lists available at ScienceDirect

Computers and Electronics in Agriculture

journal homepage: www.elsevier.com/locate/compag

An argumentation system for eco-efficient packaging material selection

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ARTICLE INFO

Article history:
Received 14 August 2014
Received in revised form 19 February 2015
Accepted 22 February 2015
Available online 11 March 2015

Keywords:
Logic-based argumentation
Argumentation tool
Decision Support System
Food packaging

ABSTRACT

Within the framework of the European project EcoBioCap (ECOefficient BIOdegradable Composite Advanced Packaging), aiming at conceiving the next generation of food packagings, we have designed an argumentation-based tool for management of conflicting viewpoints between preferences expressed by the involved parties (food and packaging industries, health authorities, consumers, waste management authority, etc.). The requirements and user preferences are modeled by several rules provided by the stakeholders expressing their viewpoints and expertise. Based on these rules, the argumentation tool computes consensual preferences which are used to parameterize a flexible querying process of a packaging database to retrieve the most relevant solution to pack a given food. In this paper, we recall briefly the principles underlying the reasoning process, and we detail the main functionalities and the architecture of the argumentation tool. We cover the overall reasoning steps starting from formal representation of text arguments and ending by extraction of justified preferences which are sent to the database querying process. Finally, we detail its operational functioning through a real life case study to determine the justifiable choices between recyclable, compostable and biodegradable packaging materials based on stakeholders' arguments.

1. Introduction

Within the framework of the European project EcoBioCap (ECOefficient BIOdegradable Composite Advanced Packaging), we have designed a Decision Support System (called DSS) whose objective is to select, for a given food, the most relevant packaging materials according to possibly conflicting requirements (food to pack, shelf life, storage temperature, packaging biodegradability, etc.) expressed by the involved parties (food and packaging industries, health authorities, consumers, waste management authority, etc.).

The DSS software, as depicted in Fig. 1, realizes a multi-criteria flexible querying process (Destercke et al., 2011) which takes as inputs desired preferences associated with packaging characteristics (dimensions, minimum shelf life, biodegradability, transparency, etc.) and uses them to query a packaging database to retrieve a ranked list of most relevant packagings. Optimal permeabilities of the targeted packaging can be computed thanks to a Modified Atmosphere Packaging (MAP) simulation model (Guillard et al., 2012). In this paper, we propose a new component of the DSS. It implements an argumentation process which aims at combining several stakeholders (researchers, consumers, food industry, packaging industry, waste management policy, etc.) requirements expressed as simple textual arguments, to enrich the querying process by stakeholders' justified preferences. Each argument supports/opposes a choice justified by the fact that it either meets or does not meet a requirement according to a particular aspect of the packagings (end of life management, transparency, etc.).

For example, a market shop manager expresses the need for a new packaging to pack apricots such that its dimensions are 20 cm in length, 15 cm in width and 15 cm in depth and ensures a minimum shelf life of 10 days. The design of this new packaging needs also to take into consideration the packaging industry constraints (ability to scale-up the production process, the availability of the row material, etc.), the waste management administration rules about packaging end of life (biodegradability, recyclability, incineration, burying, etc.) and consumer preferences (transparent packaging, environment-friendly packaging, no extra-cost due to packaging, etc.).

As illustrated in Fig. 1, the former conditions (dimensions and shelf life in addition to the fresh food to pack, i.e. apricots in this

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http://dx.doi.org/10.1016/j.compag.2015.02.012
0168-1699/

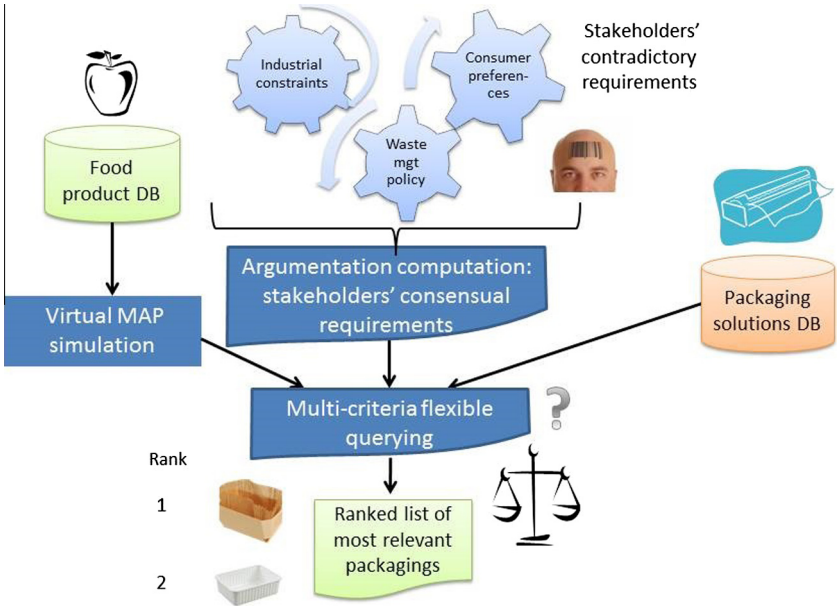

Fig. 1. Global insight of the DSS.

case) are the inputs of the virtual MAP simulator which returns the optimal parameters for gas (O_2 and CO_2) permeability to ensure the shelf life required to preserve the apricots. The latter conditions are expressed as text arguments of the form "*Biodegradable materials are suitable since they help to protect the environment*" or "*Life cycle analysis results are not in favor of biodegradable and compostable materials*". These arguments are the input of the argumentation system which distinguishes for each option (biodegradable material, compostable material, etc.) the reason leading to its acceptance or its rejection. Then, the argumentation system detects the conflicts among the arguments and computes the sets of coherent arguments which defend themselves against attacks. After that, it extracts from the winner arguments the most justified options (for instance biodegradable materials) as predicates in order to enrich the querying process. Finally, the multi-criteria flexible querying system combines the outputs of both virtual MAP system and argumentation system to deliver from the packaging solution DB the list of packaging materials satisfying the requirements.

We detail in this paper how arguments are modeled within a structured argumentation system and how the delivered justified conclusions can be used in the querying process. This paper is a detailed and an extended version of the previous work (Tamani et al., 2014).

Thus, packagings have to be selected according to several aspects or criteria (permeance, interaction with the packed food, end of life, etc.) highlighted by arguments expressed by the stakeholders involved in the project. The problem at hand does not simply consist in addressing a multi-criteria optimization problem (Bouyssou et al., 2009), but the DSS would need to be able to justify why certain packagings are chosen. To this aim, we make use of argumentation theory (Dung, 1995; Besnard and Hunter, 2008; Rahwan and Simari, 2009), in which some approaches combine argumentation and multi criteria decision making (Amgoud and Prade, 2009).

The arguments we consider in this paper are based on a defeasible reasoning. We rely in this work on a logical-based structured argumentation system, called ASPIC (Amgoud et al., 2006) and on its extension ASPIC+ (Prakken, 2010; Modgil and Prakken, 2013), which (i) allows the expression of logical arguments as a combination of atoms and rules and (ii) defines attack and defeat relations among arguments based on a logical conflict relation.

The main contributions of the work are the following:

1. An instantiation of ASPIC argumentation system (*AS*) in a DSS dedicated to the selection of packaging solutions well suited for a given food product.
2. The study of the mutual influences between arguments expressed over several options regarding different concerns. We show the limitation of the regular instantiation of the ASPIC *AS*, and we propose to overcome this limitation with a viewpoint approach in which arguments are gathered according to packaging aspects or concerns. Each viewpoint delivers subsets of non-conflicting arguments supporting or opposing a kind of packaging according to a single topic (shelf life, cost, material type, safety, end of life, etc.).
3. The use of the argumentation results for a multi-criteria flexible querying of the packaging database. The coupling of both components provides a new multi criteria decision making tool dedicated to packaging selection taking into account potentially contradictory stakeholders' preferences.
4. Implementation of the approach as a java GXT/GWT web application accessible on http://pfl.grignon.inra.fr/EcoBioCapProduction/. A demonstration video is also accessible on http://umr-iate.cirad.fr/FichiersComplementaires/DemoRomeHD.mp4.
5. Evaluation of the argumentation tool within the EcoBioCap project with a collaboration of the experts of packaging industry.

In Section 2, we detail the main functionalities of the developed argumentation tool. In Section 3, we introduce the main architecture of the developed argumentation system. In Section 4, we recall briefly our approach defining an argumentation theory relying on ASPIC. Then, we explain through a real world example the rationale behind the notion of viewpoints in Section 5. Section 6 is dedicated to the implementation and evaluation of the approach. Section 7 sums up some related works, and finally, in Section 8 we recall our contributions and introduce some perspectives.

2. Functional specification of the argumentation process

We detail hereinafter the main functions of the argumentation system integrated into the EcoBioCap Decision Support System.