Towards a general model for argumentation services

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Abstract

LA is a formal Logic of Argument which was originally developed as a flexible foundation for knowledge-level decision models, and to facilitate explanation and user-interface design. The logic has a clear semantics and is embodied in the PRO*forma* language, a simple but effective representation for modeling decisions, plans and software agents. ASPIC is an EU funded project[1] that aims to develop a general model for argumentation services (www.argumentation.org) including a consensus semantics and interchange format for argumentation in inference, decision-making, dialogue and learning. ASPIC is also providing an opportunity to extend PRO*forma* to support multi-agent services. This is being used to implement a wide range of services in multidisciplinary cancer care (ttp://acl.icnet.uk/credoweb).

Introduction

Since research on medical decision making began in the 1950s theoretical thinking about decision making has been dominated by quantitative models of rational choice. However, clinical decision making frequently departs from the requirements of formal decision theory and appears to be based on different principles. Since the 1970s psychological research on human reasoning and decision-making has confirmed differences between natural decision making and prescriptive theories (notably Kahneman and Tversky research on "heuristics and biases" and Gigerenzer's recent ideas about "fast and frugal" heuristics in which human cognition is seen as trading off accuracy for speed and reduced cognitive load.

A slightly different notion of heuristics in AI influenced the emergence of medical expert systems, in which knowledge is modelled using symbolic qualitative representations. These have often been said to be more natural for modelling and explaining clinical decisions. Design of early expert systems was ad hoc and this has given way to more rigorous approaches to representation, reasoning and decision making, frequently based on classical and increasingly non-classical logics. Argumentation systems have the strengths of logical methods but greater flexibility and robustness than classical logics. The development of LA (Logic of Argument) was motivated by the need to overcome the limitations of statistical and psychological theories of decision-making (Fox, Clark, Glowinski and O'Neil, 1990; Fox, 2003) while also providing a practical design framework that is sufficiently well grounded formally for use in clinical and other safety-critical applications (Fox and Das, 2000).

Arguments in LA are *reasons to believe* some proposition or *reasons to act* in some way. Argument structure is superficially similar to Toulmin's famous schema (Toulmin, 1958): a triple consisting of a *claim*, the *grounds* of the argument (e.g. the antecedents of an inference rule or a proof tree) and a *sign* representing confidence in the argument (c.f. Toulmin's "claim", "warrant" and "qualifier" respectively). Unlike Toulmin's model arguments are constructed according to a well-defined set of axioms (Fox, Krause and Ambler, 1992, Krause, Ambler and Fox, 1995).

To address the larger context of decision making we introduced the notion of an *aggregation function*. This captures the simple intuition that the more arguments that support a claim, and the stronger they are, then the greater the confidence that is warranted in the claim (opposing arguments reduce confidence). This approach has a straightforward rationale (Fox, 2003) and is mathematically sound (e.g. Fox and Parsons, 1998).

The framework can be instantiated in various ways. The inference model for argumentation can be based on classical or intuitionistic logic, for example. Signs may be drawn from different "dictionaries", such as the simple dictionary *{supporting, opposing}* (often abbreviated to {+,-}) or the larger dictionary *{confirming, supporting, opposing, excluding}* in which *confirming* and *excluding* dominate weaker *supporting* and *opposing* arguments. We also permit signs to be quantitative, drawn from the [0,1] interval for example, to represent the strength of arguments. These can be aggregated with standard probabilistic or decision theoretic methods.

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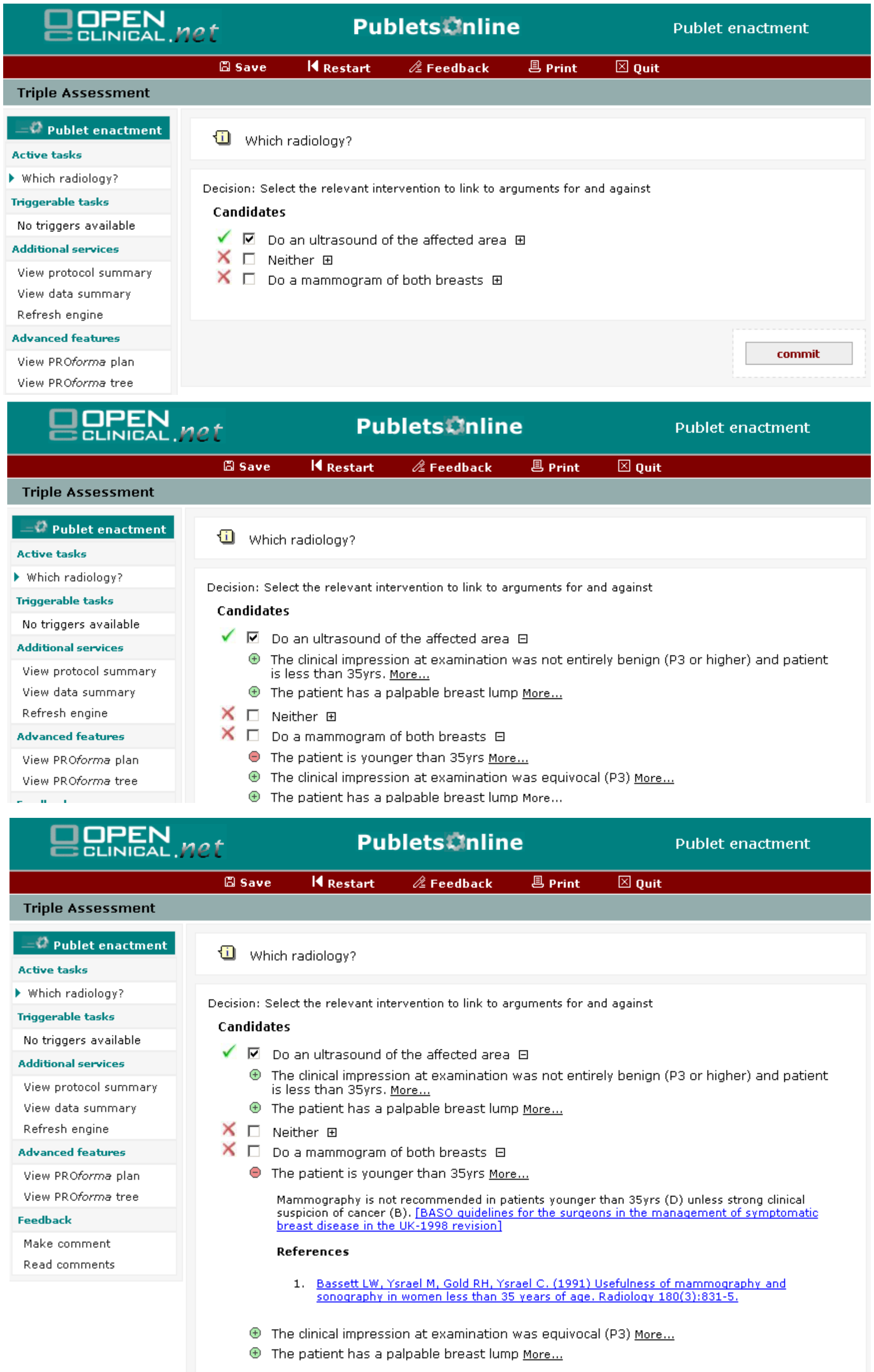

Figure 1. *Decision support system for advising on choice of imaging in diagnosis of suspected breast cancer. Top panel shows the decision candidates (competing "claims"), indicating their decision status as recommended (checked) or excluded (crossed) ; middle panel exapands to show arguments for and against each candidate; bottom panel expands the arguments to show the justification or backingfor a selected argument. ("Backing" is Toulmin's term). Here the backing is in terms of published evidence for the argument (which may be accessible from Pubmed or other source).*

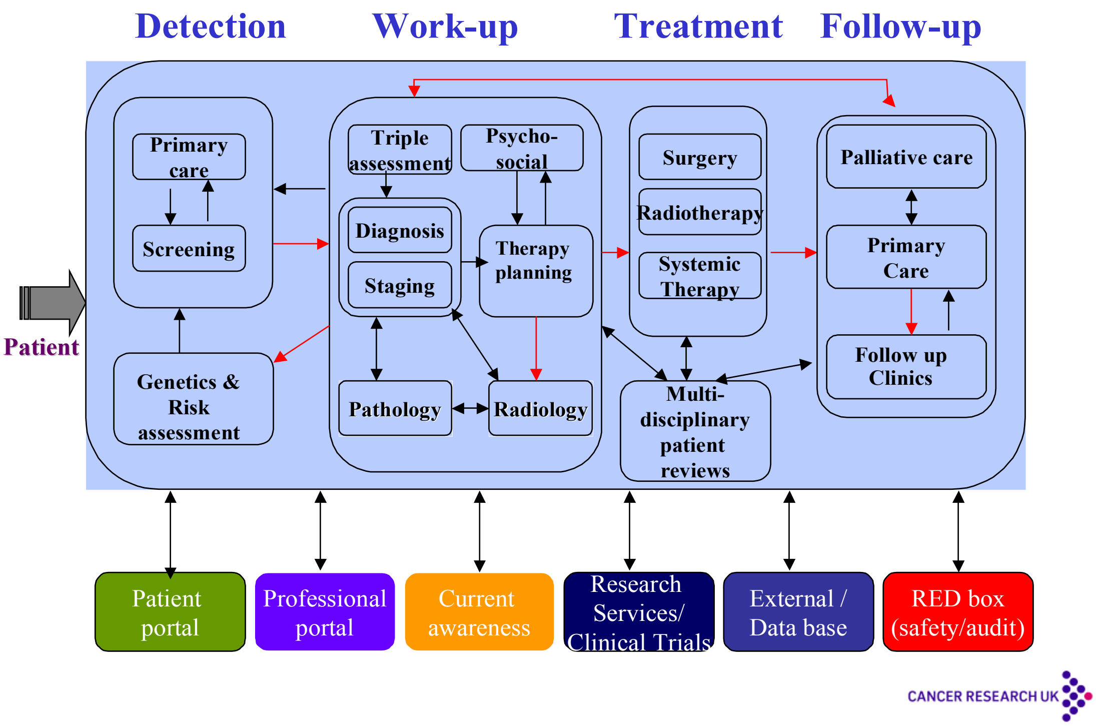

Figure 2: *High level model of an integrated care pathway for management of breast cancer (large rectangle). Activities flow roughly from left to right, with messages and data flowing between specialty services along the arrows. Each internal box includes a set of clinical or administrative services modelled in PROforma and external boxes represent access points for different stakeholders (e.g.web portals for professionals, patients, researchers.).*

Much of the work of our group over recent years has centered on the development of a process modelling language for medical care, PRO*forma* (see Fox and Das, 2000, and www.openclinical.org/gmm_proformal.htm), which builds on the LA framework outlined above. The LA framework forms the decision model for PRO*forma*. The language is based on an upper ontology for modelling business processes (plans, decisions, actions and enquiries) and facilitates the creation of user interfaces in which argumentation provides a natural way of giving explanations in terms of claims, grounds etc (Figure 1).

Practical applications and results

A substantial body of evidence has been accumulated that LA and PRO*forma* are effective foundations for medical applications in primary care (e.g. Emery et al. 2000, Walton et al, 1997), specialist care (e.g. Taylor, Fox and Todd-Pokropek, 2002, Tural et al, 2002) and in clinical research (e.g. Bury et al., in press). We have also found that these methods provide a good basis for explaining and justifying advice as illustrated in figure 1. We have specifically investigated the value of argumentation based user interfaces in genetic risk assessment and counselling. RAGs is a tool for taking a family history and assessing genetic risk of breast & ovarian cancer (Coulson et al., 2001). RAGs was compared with a conventional statistical system and it was found that 93% of primary care practitioners preferred the argument based presentation (Emery et al., 2000). REACT is a "what-if" planning tool combining real-time updating of risk and argument displays which has been judged a valuable tool by initially sceptical genetic counsellors (Glasspool and Oettinger, submitted).

The CREDO project

The triple assessment application in figure 1 is one of a number of services we have developed for supporting the care of women at risk of contracting breast cancer, or are suspected or have proven breast cancer. Our current aim is to develop a comprehensive clinical workflow and decision support system for the whole "cancer journey" using PRO*forma* and REACT. The CREDO service model for

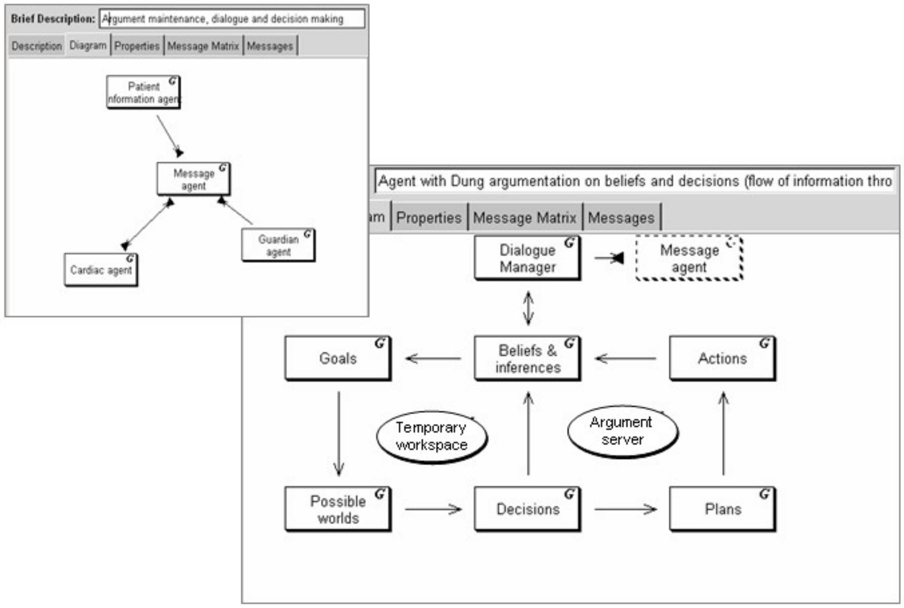

Figure 3: *Simulation of a multi-agent scenario in which 3 agents collaborate in managing a hypothetical patient with chest pain (left). Agents are organised on the domino framework proposed by Das et al (1997) shown on the right.*

breast cancer is shown in figure 2.

CREDO is intended to automate a substantial proportion of the main workflows in a multidisciplinary care pathway for breast cancer (large panel in figure 2). This encompasses approximately 220 services, and 65 significant clinical decisions. The aim is that many services will be accessible by different stakeholders with different goals and roles, including professionals (oncologists, surgeons, nurses, GPs etc), researchers, and the patients themselves. Use of a formal process modelling language like PRO*forma* permits separation of the service logic from the user-interface and dialogue layer, and permits different presentations for different users (e.g. selective and more informal presentation of argumentation for patients). In designing these interfaces a number of principles are observed, including the need for:

- Intelligibility: permitting natural and cooperative dialogues for the user, based on shared assumptions about personal goals, expectations and plans.
- Accountability: services should "know" what they are doing and why, and be able to explain their actions or recommendations.
- Empathic: sharing some of the user's everyday understanding of the world (e.g. human concepts like "belief", "goal", "intention") which can be given intuitive as well as formal interpretations (e.g. see Fox and Das, 2000)
- Ethicality: facilitating the incorporation of basic policies and norms of confidentiality, fairness, trust and so on.

Current logic and argument theory have major contributions to make to these objectives, but this prospectus can only be fully achieved if we understand more deeply the roles and foundations of certain common-sense concepts that underlie argumentation. These are among the objectives of the ASPIC project.

"Argumentation Service Platform with Integrated Components"

ASPIC is an EU funded research project (www.argumentation.org) whose goals are to develop a theoretical consensus for four roles of argument (in inference, decision-making, dialogue and learning) and validate it within the context of a general software agent. It primarily concerns artificial agents but the interests of our group include relating the theory to current ideas about human expertise, with which there appear to be strong convergences (Fox and Glasspool, Glasspool 2004). If confirmed we believe this will suggest important ways of improving interaction between software agents and their human users in healthcare and other applications.

Figure 3 shows a general agent model under development within ASPIC. It is a version of the "domino" agent (Das et al., 1997, Fox and Das, 2000) extended to include inter-agent dialogue capabilities and learning. ASPIC is studying a variety of medical scenarios, such as the "guardian agent" scenario in figure 3 which shows a simulation of three agents collaborating in the management of a hypothetical patient with chest pain (left panel). Here a *patient information agent* informs a *cardic agent* about an elderly patient with chest pain and other data. The CA argues the *pros* and *cons* of alternative diagnoses and interventions and suggests a treatment. However, in some circumstances the argumentation for the decision may be inconclusive so a *guardian agent* with specialist safety knowledge advises on the final decision. The CA and GA are organised on the domino model (right panel) in which data flows from process to process along the arrows.

In the agent in figure 3 the basic domino has been augmented with a temporary workspace, a dialogue manager and an argument server. The last implements recent developments in argumentation theory. Since LA was described another formal interpretation of Toulmin's ideas have gained attention in AI. This puts Toulmin's notion of *rebuttal* at the centre and is based on the idea of arguments "defeating" one another. Defeasible logics first introduced by Nute, Pollock, Loui and others and have been formalised in Dung's calculus of defeat (Dung, 1995). The motivation for making defeat so central arose in part because of the idea of the need for a computational framework for supporting negotiations and joint deliberations between agents. In the ASPIC agent this version of argument is used to model non-monotonic reasoning about beliefs and inter-agent dialogues. However, for decision-making where we need to weigh up collections of arguments for competing beliefs (e.g. alternative diagnoses or risks) or actions (e.g. treatments or other actions) we have combined the Dung approach with the ideas of argument weighting and aggregation. This is addressed by adding LA-style qualifiers (and associated aggregation rules) as set out in the Introduction, to Dung-style arguments. Dung's approach may then be used to determine a set of arguments which are not defeated, and the LA-style qualifiers on those arguments may then be used to aggregate them to provide a single "support" value to be used in decision making.

ASPIC has made significant progress, including a stable consensus on formal models of argumentation for inference and decision-making, an emerging consensus on argument-oriented speech acts in dialogue, and in roles of argumentation methods in agent design. Completed reports and papers can be found at the project web site www.argumentation.org. Current priorities include development of an argument interchange format and data schema, an advanced agent modelling language, and technology demonstrators. The latter will include healthcare applications and we hope to be in a position to report progress towards these goals by the time of the symposium.

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