PROforma progress

John Fox, Jon Bury, Michael Humber, Ali Rahmanzadeh, Margarita Sordo

REACT group
David Glasspool, Tito Castillo, Vicky Monaghan
PROforma technology (MIE 96)

- FO logic language for modelling decision-making and workflow in uncertain and time-evolving environments
- Integrating rule-based, object-oriented and task-network paradigms
- Formal notation for specifying tasks and processes
- Graphical and CASE tools for authoring task networks
- Language has procedural as well as declarative reading, permitting machine enactment of PROforma specifications
PROforma “tasks”

A task is an encapsulated body of knowledge designed to achieve a specific clinical objective, either in isolation or as a component of a more complex process. The knowledge encapsulated in a task typically includes both logical and control knowledge. A task can often be viewed as a module that may be reused across applications.
PROforma theory

• Brings together ideas from mathematical logic, psychology of reasoning and judgement, and AI
• Clinical “agents” use an extended BDI model which supports task objects, decision making under uncertainty, plan enactment
• Formalised in terms of classical and non-classical logics

Fox and Das, Safe and Sound, MIT Press 2000
“Minimal” task ontology

Abstract task

- Plans
- Decisions
- Actions
- Enquiries
PROforma development lifecycle

1. Application requirements
2. Process model
3. Specify task definitions
4. Verification and testing
5. Delivery
Arezzo® toolset

• Well engineered development environment
  – Graphical authoring tool
  – Ontology modeller
  – Enactment engine
  – Syntax-directed editor and model-checker
  – Integrated tester

• Arezzo 2i (2000) version supports web delivery and other refinements

*InferMed (1998)*
Arezzo decision editor
PROforma language syntax

• Formal specification language for modelling the process component of clinical expertise
• First-order language supporting
  – The concept of task (minimum ontology)
  – Data and concept definitions
  – Temporal expressions
  – Arithmetic and other common functions etc. etc.
• Syntax definitions available as
  – BNF
  – DTD
**PROforma language semantics**

- **Support role or autonomous agents**
  - BDI model augmented with temporal reasoning and uncertainty management
- **Data and knowledge representation**
  - Equiv to Horn clause logic (closed world negation)
  - Argumentation for decision making
  - Logic of obligation and time for scheduling
- **Task enactment**
  - Sequential or parallel pathways
  - Synchronous (scheduled) or asynchronous execution
Shared features with other reps

- Rules and functions encapsulated in tasks
- Tasks composed into time-oriented networks
- Nesting of processes (through plans)
- Support forseriality, concurrency, iteration
- Explicit support for decision making
- Interface primitives (actions, enquiries) through API
Distinctive features

• “Minimal” task ontology
• Focus on process, not patient data, ontological tools etc. (we aim to provide APIs for these)
• Concern with formal issues:
  – Clear semantics
  – Verification and validation
  – Explicit safety management
• Autonomous operation as well as support modes
• Generic agent model (not necessarily clinical)
Current ICRF research: Clinical applications
RAGs: Risk Assessment in Genetics
Andrew Coulson, David Glasspool
Jon Emery (CRC Fellow) and GPRG, Oxford
REFERRAL ADVICE

It would be appropriate to refer this patient to the breast clinic.

Currently it is unlikely that she will be a candidate for gene testing but additional screening for breast and/or ovarian cancer will be discussed.

Patient Assessment Report

The following information applies ONLY to the highlighted path.

This patient is at moderate risk of being a gene carrier because, on the highest-risk path of inheritance found by the program:

* The mother of the presenting patient is affected, which indicates an increased risk level.
* One first-degree relative (FDR) is affected (Each affected FDR indicates an additional risk factor).
* One affected FDR has an onset age under 50, indicating a moderate increase in risk
* The combination of one breast and one ovarian cancer indicates a moderate increase in risk level.

However, this is balanced to some extent by the following factors which indicate lower risk level:

* The oldest affected second-degree relative has an age of onset over 60. Genetic predisposition is more likely to be associated with lower ages of onset, and this age indicates a considerable reduction in risk level.
* Genetic predisposition is less likely in a person over 40 who has not developed cancer.

Overall, the likelihood that this patient is a gene carrier is moderate.
Primary care referrals: ERA
Jon Bury, Michael Humber
To use ERA, you will need Microsoft Internet Explorer 5 or above (get the latest version).

ERA - Early Referrals Application

To make a referral, click on "Electronic referral" under the appropriate heading (ERA overview and tutorial).

Lung
- Electronic referral
- Key points
- Referral guidelines

Breast
- Electronic referral
- Key points
- Referral guidelines

Upper Gastrointestinal
- Electronic referral
- Key points
- Referral guidelines

Colorectal
- Electronic referral
- Key points
- Referral guidelines

Haematological
- Electronic referral
- Key points
- Referral guidelines

Sarcoma
- Electronic referral
- Key points
- Referral guidelines

Skin
- Electronic referral
- Key points
- Referral guidelines

Neurological
- Electronic referral
- Key points
- Referral guidelines

Gynaecological
- Electronic referral
- Key points
- Referral guidelines

Head and Neck
- Electronic referral
- Key points
- Referral guidelines

Urological
- Electronic referral
- Key points
- Referral guidelines

Paediatric
- Electronic referral
- Key points
- Referral guidelines
### Patient Details:

**Age:** 47  
**Gender:** Female

### Referral Information (please tick boxes):

#### Breast Lumps:

- **Discrete Lump:** Yes [ ] No [x]  
- **Asymmetrical Nodularity Persistent at Review After Menstruation:** Yes [x] No [ ]
- **Abscess:** Yes [x] No [ ]  
- **Persistent / Refilling Cyst:** Yes [ ] No [ ]

#### Skin Changes:

- **Nodule:** Yes [ ] No [x]  
- **Distortion:** Yes [ ] No [x]  
- **Ulceration:** Yes [ ] No [x]

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#### Pain:

- **Intractable Pain:** Yes [x] No [ ]

#### Nipple Discharge / Changes:

- **Discharge:** Yes [x] No [ ]
- **Blood Stained:** Yes [x] No [ ]  
- **Large Volume (Sufficient to Stain Clothes):** Yes [ ] No [x]
- **Bilateral:** Yes [x] No [ ]
- **Eczema:** Yes [x] No [ ]
- **Recent Retraction or Distortion (≤3 mths):** Yes [ ] No [x]
ERA recommendations
These are made on the basis of the clinical features presented to the system, they are intended to aid, not replace, clinical judgement:

A 2-week referral may not be appropriate because none of the standard indications for a 2-week referral apply to this patient.

A referral to a breast specialist, though not necessarily urgent, would be appropriate

The following criteria apply to this patient:

- asymmetrical nodularity persistent at review after menstruation

Patient Details:

Age: 47  Gender: M  F  F

http://www.infermed.com/wap/era
Open source knowledge?

- **PROforma Guideline: Breast**
  - plan: Breast
  - enquiry: Clinical Information
  - decision: Referral decision
  - action: No two week referral
  - action: Two week referral
  - action: Non urgent referral

```xml
<!DOCTYPE decision (View Source for full doctype...)>  
<decision name="Referral_decision"
  choice_mode="single" support_mode="symbolic">
  <caption>Referral decision</caption>
  <candidates>
    <candidate name="Two_week_referral">
      <arguments>
        - <argument support="for">
          <proforma_condition>
            ( tissue_changes includes 'Discrete lump' and age >= 30 )
          </proforma_condition>
        </argument>
        - <argument support="for">
          <proforma_condition>
            ( skin_changes includes Ulceration )
          </proforma_condition>
        </argument>
        - <argument support="for">
          <proforma_condition>
            ( skin_changes includes Nodule )
          </proforma_condition>
        </argument>
        - <argument support="for">
          <proforma_condition>
            ( skin_changes includes Distortion )
          </proforma_condition>
        </argument>
      </arguments>
    </candidate>
  </candidates>
</decision>
```
Acute Lymphocytic Leukaemia

Jon Bury with ICRF Clinical Databases group and The London Hospital Paediatric Oncology Unit
Overview of patient status

New data requested

Guidance on treatment is automatically generated
Palliative care: Arno
MACRO trial manager
## Arezzo applications

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InferMed Ltd.
Current ICRF research
New research release

• Refined language syntax and semantics
• New Java toolset
  – Composer
  – Tester
  – Engine
  – Web server
• PROforma reference engine
REACT care planner

David Glasspool,
Tito Castillo
Vicky Monaghan
“Publet” technology
Ali Rahmanzadeh
David Sutton