Manuela M. Veloso

Computer Science Department
Carnegie Mellon University
veloso@cs.cmu.edu
(412) 268-8464
http://www.cs.cmu.edu/~mmv/

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More details are available off the ARPI TIEs’ Web page, or directly in http://www.cs.cmu.edu/~mmv/arpi-mi.html.

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TIE Description

Rationale Capture and Reuse in Mixed-Initiative Planning

Alice Mulvehill, Mitre
Steve Christey, Mitre
Manuela Veloso, CMU
Michael Cox, CMU

Integrate the capabilities of Prodigy/Analogy and ForMAT for the continued acquisition and generation of planning cases.

The goal is to support the user with an interactive environment where past cases can be recalled and adapted interactively by the user or automatically using the rationale underlying the original plan.

As a starting point we will experiment with the existing force module case-base of ForMAT and we plan to extend our efforts to include the Air Campaign Planning domain.
The Scenario

- Two developed and large systems: ForMAT and Prodigy.
- Two different environments:
  - CMU - academic, little knowledge of users
  - Mitre - government lab, large knowledge of users
- Two different perspectives:
  - ForMAT
    * user-driven case-based planner
    * real cases stored (deployment TPFDDs)
    * sophisticated browsing and retrieval
    * case functional analysis
    * no automated adaptation
  - Prodigy and Prodigy/Analogy
    * fully-automated planner
    * well-structured domain knowledge
    * manufactured domains (even if realistic)
    * disciplined knowledge organization
    * interpretable planning cases
    * full-automated storage, retrieval, and adaptation
Making it Possible to Proceed

- Layered system understanding: decomposition of system at different levels of detail.
- Effort to break the terminology gap between users and research communities.

“Stubbornness” to make it work!

- Aim to identify issues already solved by the technology developed in research systems.
- Determination to find new research issues.
Snapshot of ForMAT’s Interface

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Partial Abstraction Hierarchy:

- **TOP-TYPE**
  - AIR-FORCE-MODULE
  - GROUND-FORCE-MODULE
  - CITY
  - COUNTRY
  - FIGHTER
  - REFUELING
  - POLICE-FORCE
  - SPECIAL-FORCES
  - INFANTRY
  - ARMOR
  - INFANTRY-BATTALION
  - BRIGADE
  - 21ST-DIVISION-READY-BRIGADE

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Commander's Mission Statements

"Goal: Provide military police to secure the town and the air strip in Tuzla so that military a/c can land there.

Deploy 3 squadrons of A-10s to Aviano to provide CAS to the Bosnia A OR (Area of Responsibility)."

"Goal: Need a Hawk unit and the 21st Division Ready Brigade to send to Korea to secure an airport. Also want to provide security police to keep the airbase secure so that 3 squadrons of A-10As can be forward deployed there."
Snapshot of ForMAT’s Goal Editor
Goal Representation

(:GOALS
(146 :SEND-SECURITY -POLICE
((FORCE NONE) (FORCE-Q U ANTITY 1) (GEOGRAPHIC-LOCATION K OREA))
)
(145 :SEND-BRIGADE
((FORCE 21ST -DIVISIONREAD YBRIGADE) (FORCE-Q U ANTITY 1) (GEOGRAPHIC-LOCATION K OREA))
)
(144 :SEND-HA WK
((FORCE HA WK-B A TT ALION) (FORCE-Q U ANTITY 1) (GEOGRAPHIC-LOCATION K OREA))
)
(143 :SECURE-AIRPOR T
((GEOGRAPHIC-LOCATION K OREA))
)
(142 :DEPLO Y-A10A
((GEOGRAPHIC-LOCATION K OREA) (AIRCRAFT -TYPE F15) (AC-Q U ANTITY 3))
)
)

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Goal Representation

(TOWN-CENTER-SECURE AT BOSNIA) (EXISTS ((M-P) MILITARY - POLICE) (IS-DEPLOYED <M-P> BOSNIA)) (EXISTS ((A) A10A) (IS-DEPLOYED <A> BOSNIA))) (AIRPORT-SECURE AT BOSNIA)
Feedforward Control

Goals

PRODIGY

Translate
Use as Retrieval Probe
Use to Plan
Old Case (Plan)
New Generate
Use as Guidance
Use as Check

If Successful Plan
Then Continue

Control
Provide Suggestions
to User

To ForMAT

From ForMAT

Plan

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Example Message from Prodigy to ForMAT

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Suggested Plan Modifications

- Change POD, POD-CC, DEST, and DEST-CC to places in or near BOSNIA in FM (FM DEL PLANJ)
- Add or create a Force Module to address goal (:SECURE-TOWN-CENTER-HALL (AIRCRAFT-TYPE NONE) (FORCE NONE) (GEOGRAPHIC-LOCATION BOSNIA) (AC-QUANTITY NONE) (FORCE-QUANTITY NONE)).
- Remove BRIGADE Force Module from Plan.
- Remove HAWK-BATTALION Force Module from Plan.
- Change SECURITY-POLICE to MILITARY-POLICE.
- Change F-15 to A10A.
- The goals of PLANC are most similar to this plan.
- The following cases are also relevant: (PLANE).
Feedback Control
Suggested Case Modifications
Reject Accept Suggestions
Negative Example Positive Example
To PRODIGY From FORMAT
Incorrect Correct
User not Committing
Ambiguous Example Ignore
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Main Research Issues Addressed

- Interpretation of users’ objectives and scenario into rationale and action model.

- Under-specified goal statement from users: planner plans for existentially quantified goal statements.

- Users specify goals that are subgoals of other goals: planner focuses on higher-level goals and refinement brings up the subgoals.

- Users expect plans of good quality: selection of resources to opportunistically achieve multiple objectives.

- Definition of communication triggers to enable interaction.

- Class organization of planning actions (e.g. all the "send" operators) – some fully subsume others.

- Learning from users’ history and reaction to guidance suggested.
Prefer - More-Specific-Op

Given two operators from which to choose, prefer the more specific one.

Prefer - Top-Most-Goal

Given a choice between two goals, prefer one if making the other true solves one of the preconditions for an operator that results in the preferred one (or is likewise further removed).

Prefer - Bindings-Opportunistically

Given a current operator and candidate set of bindings, prefer those bindings that opportunistically solve some other top-level goal.

(Control-Rule
  (if (and (candidate-goal <G1>) (candidate-goal <G2>) (solves-precondition-of-p <G1> <G2>))
   (then (prefer goal <G1> <G2>)))
   )
FORMAT supports the following capabilities:

1. User receives the text description of a new mission;
2. User queries database of past plans;
3. User browses past plans;
4. User refines query incrementally;
5. User uses objective representation to specify the goals of the new mission;
6. Plans and their Force Modules (FMs) are stored, indexed by goals and scenario information.

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In PRODIGY/Analogy, the following features are used:

1. Objects (such as units, locations, FMs) are organized in a class ontology;
2. Plan actions are modeled and represented as plan operators;
3. Planner can generate plans at a high level of abstraction;
4. Plans are stored, indexed by goals and scenario;
5. Plans are retrieved based on goal similarity;
6. Rationale is used to propose appropriate modifications.

Carnegie Mellon, M. Veloso, ARPI TIE, 1996, ForMAT/Prodigy-Analogy
FORMAT/PRODIGY provides mixed-initiative plan retrieval and modification through the following features:

1. FORMAT and PRODIGY exchange messages in real time;
2. FORMAT sends user's actions to PRODIGY;
3. PRODIGY can follow user's plan browsing history;
4. FORMAT's user saves goals: PRODIGY plans at the force module level;
5. PRODIGY retrieves plans with similar objectives (goals);
6. PRODIGY sends suggested plan modifications driven by plan rationale;
7. FORMAT's user processes received mission statement.

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What DID NOT and DID Work

- **DID NOT:** Automated translation of TPFDDs into classic planning operators.
  
  -- Seemed feasible, because there is a large set of rules (250) that explains the meaning of each field.
  
  -- Became infeasible, when several inconsistent and incomplete situations were found between users’ practice and the rules.

  -- **DID:** Definition of simpler planning model that allows the automated planner to plan at the force module level.

- **DID NOT:** Automated understanding of ForMAT log files.
  
  -- Seemed feasible, because a log file is system generated and therefore contains closed-world statements.

  -- Became infeasible, due to the complexity of the possible combinations of users’ actions, of the users’ browsing, and of the users’ “mistakes” or “mind changes.”

  -- **DID:** Definition of communication triggers to focus systems’ attention to each other.
The Rewarding and Real Facts

It works!

- Communication links: No need to fully delve into the systems.
- Much better appreciation of systems’ contributions.
- Use of case-based planning technology was appropriate to bridge the gap between human and machine planners.
- Several challenging research issues were identified.
- Better understanding of users’ planning practice.

Users have long history of planning practice.

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Summary - Some Contributions of TIE

• ForMAT can run with Prodigy/Analogy providing guidance to user.

• Integration of automated planning with a user planning interface.

• Handle of weak rationale available: suggestions of modifications.

• User can ignore, accept, or reject guidance.

• Learning opportunity through history of user’s reaction to guidance.
The Progress Curve

- Positive second derivative: enthusiasm, trust, some lack of realism
- Plateau: the overwhelming reality
- Steepest slope: simplification, persistence, dedicated effort