Modeling the Human Operator’s Cognitive Process to Enable Assistant System Decisions

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Agenda

- Manned-Unmanned Teaming (MUM-T)
- Assistant System Approaches for MUM-T
  - Assistant System Requirements
  - Recognizing the Operator‘s Current Activity
  - Evaluating the Operator‘s Plan
- Human Operator Model
Manned-Unmanned Teaming (MUM-T) Crew Concept
Manned-Unmanned Teaming (MUM-T) Crew Concept

- **Virtual Pilot View**
- **UAV Camera View**
- **UAV Guidance**
- **Helicopter Displays**

**UAV Operator**

**Helicopter Pilot**
Operator will be overtaxed!
(multiple aircraft mission replanning)

Recconnaissance Tasks

Task-based Interaction

UAV selection
Manned-Unmanned Teaming (MUM-T)

Assistant System Approaches for MUM-T
- Assistant System Requirements
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Human Operator Model
Assistant System for UAV Operator

- Assistant system shall guide attention to most urgent task and intervene if necessary
- Assistant system communicates via *speech synthesis monolog* and *display dialog*
- Three initiative levels: *advice* → *proposal generation* → *task re-allocation*
Example for Human-Machine Dialog

- Assistant System takes initiative: “UAV1 needs follow-up task”
- Operator presses proposal-button
- Assistant System proposes: “add task transit A B for UAV1”
- Operator presses accept-button
- Assistant System affirms: “added task transit A B for UAV1”
- etc.
• Goal structure:

- Basic desire: Support operator
  - Operator workload balanced
    - Know operator workload
  - Operator works on most urgent task
    - Know actual operator task
    - Know most urgent task
  - Task costs acceptable
    - Predict task costs

- Questions the assistant system has to answer in order to decide whether to take initiative...

- Is operator's plan good (contributing to mission goals)?
- What should operator plan?
- Does operator follow the plan?
- Is operator overtaxed?

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Estimating Operator’s Current Workload and Task

Most probable task and workload situation:
Target identification with 3UAVS, using self-adapting strategy SAS 2

Visual & manual touchscreen interactions

Multi-UAV operator

Target identification (1UAV)
Target identification (3UAVs)
Threat replanning (1 UAV)
Threat replanning (3 UAVs)

Workload
Normal workload → Critical workload

Each cube represents one HMM

...So far only offline...
Mixed-Initiative Mission Planning

1. System plan is entered incrementally → partial human plan

2. Assistant System has direct access to system plan

3. Assumed human plan is the best known completion of the system plan (LPG in incremental mode)

4. Assistant system takes initiative on basis of assumed human plan (to enforce action scheduling, to correct missing of actions) and in case there are completely new mission goals (offer ref. plan)

→ top-down plan „recognition“

→ Srivastava et al. (2007) generating diverse plans via local search (LPG-d)
→ Nguyen et al. (2009) working with partial user preference models
Further Assistant System Functions Overview

• Estimating operator‘s current mental resource utilization / capacity (online)
  – to adapt information channel used by assistant system
  – precondition: we have to know about operator‘s current
    • task situation (to match with a task-resource model)
    • activity (e.g. radio transmission, looking at display x)

• Improving gaze tracking data quality for online decision-making
  – data about operator‘s situation awareness (beliefs)
    → which map object looked at, which message read
  – precondition: know about operator‘s task situation
    → Kalman Filtering
Manned-Unmanned Teaming (MUM-T)

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Human Operator Model
Intent Recognition from a Human Factors Engineering Point of View

Human operator’s cognitive state

workload

goals

plan + e_p

action + e_a

behavior + e_b

effects

suffers from has has chooses shows generates

estimates assumes assumes recognizes measures measures

Human Error: Mistakes, lapses, slips (Reason 1990)

Machine inferring about human’s cognitive state
Human Operator Model based on BDI-like Model

- **Environment**
  - External world
  - Information processing
  - Error
  - Information acquisition
  - Manipulation

- **Beliefs**
  - Internal world
  - Goal prioritization
  - Workload
  - Error
  - Prioritization
  - Action selection

- **Goals**
  - Action
  - Execution
  - Behavior
  - Plan
  - (Re-)planning
Human Operator Model based on BDI-like Model

**situation awareness**

agent may reveal information about its intent directly
\[\rightarrow\] reasoning about following steps becomes simplified

**preferences**

rational agent with error and performance deviations

- models of deviating behavior (SAS)
- cmp. traces (e.g. entered plan vs. ref.)
- cmp. interpreted traces (plan costs)

**Environment**

Beliefs

Goals

Behavior

IFS

external world

inf. processing

goal prioritization

(re-)planning

situation awareness

preferences

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Thank you very much for your attention!

Comments and questions welcome...

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