Human Activity Modeling in RESCUE

Centre HCI Design
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Learning Objectives

Three key objectives:

- To understand the benefits of integrating human factors work into the requirements process
- To develop skills in gathering data for human activity models
- To develop skills in modeling human activity
Tutorial timetable

am:  Background and overview
     Gathering data for human activity modeling
     Exercise: planning data gathering

pm:  Modeling human activity
     Exercise: developing the plan
     Summary and conclusions
Part 1: Background and Overview
Who Shot the Terminal?

The National Electronics Council reports the following anecdote from the Human Factors Society Bulletin:

The manager of a system installation for police and sheriff departments reported that one day he received the call: `Your terminal is dead. Come and get it.' He suggested that the repair service should be contacted, but the caller insisted that he go out and visit it.

The terminal had two bullet holes in it. Apparently an officer got `Do not understand’ on the screen one time too many, so he stepped back and shot it!
Critical and Deadly Failures

Examples where insufficient consideration of human factors issues has lead to unsafe critical systems are numerous, eg:

– London Ambulance Service scheduling system that lead to delays in reaching seriously ill people
– Aircraft crashes (eg one at Kegworth) due to problems pilots experience with interpreting cockpit data displays
– Three Mile Island and other nuclear disasters due to poor control panel and alarm design
Activity Modeling: Overview

• Human activity modeling is about developing an understanding of the current socio-technical system which can inform the specification of a future system.

• Focus is on human users of the technical system to enable us to focus on ‘human-centred automation’

• An activity model is a repository of information about various aspects of the current system including: actors, resources, goals, actions, resource management strategies, constraints, and contextual features (ARGARCC)
Activity Modeling: Overview Continued

- **OCU**
- **ORD**

Human Activity Modeling

Modeling and specification of future system
(i*, use cases, requirements)
Activity Modeling: Motivation

• Generating requirements for complex socio-technical systems
  – Implies not only capturing stakeholders needs, but also understanding the way in which practitioners interpret the goals of the work domain and its constraints, developing appropriate (or less than) strategies to cope with them

• Introducing artefacts (tools, procedures, automation)
  – Changes the way practitioners work and process information. It also brings about changes in the co-operative, and possibly organisational, structures
  – Generating requirements has to reflect an understanding of how the new artefacts might potentially change existing work practices
Activity Modeling: Purpose

- Inspires and motivates requirements
- Inspires high-level design visions

- Identifies non-prescribed as well as prescribed elements of the system
  - non-prescribed actors, resources, goals and resource management strategies are ways of “finishing the design”
  - may make the system more flexible or increase redundancy, therefore increasing safety
Activity Modeling: Purpose Continued

In terms of the RESCUE process, activity modeling:

• Develops understanding of system boundaries
  – what may be automated, what is to remain under the control of the controllers (e.g., handling exceptional conditions)

• Source of data for i* modeling

• Source of data for use case description

• Provides contexts for scenario walkthroughs

• Identifies fit criteria for requirements (and hence criteria for evaluating system)

• Helps assess impact of proposed system
Human Activity Modeling

First synchronization stage
- Gather data on human processes
- Model human activity
- Determine system boundaries
- Develop use case model
- Define system-level requirements

Second synchronization stage
- Determine system dependencies, goals and rationale
- Describe use cases
- Define and document requirements
- System-level requirements in VOLERE shell

Third synchronization stage
- Refine system dependencies, goals and rationale
- Specify use cases
- Define and document requirements
- Use cases associated with requirements

Fourth synchronization stage
- Use case specifications
- Walkthrough scenarios
- Define and document requirements
- Scenarios associated with requirements
- Impact analysis
- Refine and change requirements
Uses of Human Activity Modeling

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Impact analysis
- Refine and change requirements
Part 2:
Gathering Data for Human Activity Modeling
What to Look For

• Gather data relevant to all components of an activity model
  – actors, resources, goals, actions, resource management strategies, constraints, contextual features

• Focus on identifying non-prescribed elements and understanding less obvious actions
  – eg non-direct communication (watching and listening), looking over someone’s shoulder can be important in achieving overall goals
  – often identified through inference from various data gathering techniques

• Identify constraints and sources of variability
  – environment and context constrain, subjective factors lead to inter- and intra- controller variability
What to Look For (Continued)

• Look out for **cognitive** components of activity
  – eg cognitive resources, goals, actions, resource management strategies, constraints or contextual features

• Look out for **social** or team elements
  – eg co-operation of other actors as a resource
  – collective goals which can only be achieved by a number of actors working together
  – actions involving communication between actors
  – trust (or lack of it) in other team members may act as a constraint

• Look out for elements relating to **individual** actors’ attitudes or pre-dispositions
  – eg attitude to risk and its affect on decisions
  – response to high workload
How ...

• Usually need a combination of different techniques
  – different techniques tend to elicit different kinds of data
  – data gathered using one technique may be used to confirm inferences made on the basis of data from another technique

• Don’t pre-judge relevance of information
  – inherent non-determinism of complex and open socio-technical systems means that any data may be relevant
Techniques for Gathering Data

Techniques include:

• Observation
• ‘Scenario’ walkthroughs
• Interviews
• Use of verbal protocols
• Ethnography
• Contextual inquiry

…. or some creative mixture of the above!
Observation

• Analyst observes the work domain and activity, and records findings
  – using notes, audio and video recording
• May be done in the lab or in the field
• Useful for:
  – gathering information about activities which have observable behaviour or stages (therefore not cognitive activities)
  – gathering information about activities that involve many individual steps which may be omitted in a verbal description
  – gathering information when a task is difficult to verbalise, especially for skilled performers
• Limitations:
  – time-consuming
  – involves inference in interpreting the data
Scenario Walkthroughs

- Scenarios here are **NOT the same** as those used later in RESCUE
  - scenarios here are ‘informal narrative descriptions’ with variable detail
  - scenarios use **vocabulary and phrasing of users**: they are individual and personalised accounts
  - scenarios may be supported by **additional artefacts** (pictures, screen shots)
  - **walkthroughs are less structured** than those carried out later in RESCUE

- Elicited in interviews
- Used here to explicate **existing** work situations
- Useful for identifying actors, resources, goals and actions
  - constraints, contexts and resource management strategies may also be identified through inference
Interviews

• Useful for obtaining information which is difficult to elicit using other approaches
  – eg general principles, background knowledge, reasons behind behaviour, infrequent events, attitudes

• Limitations:
  – time-consuming to conduct, transcribe and analyse
  – danger of analyst bias towards own interests, knowledge and beliefs
  – self-reported claims about current behaviours are unreliable, as are speculations about the future

• Three different types:
  – **structured**: pre-determined questions, fixed order
  – **semi-structured**: questions determined in advance but may be reworded, re-ordered, explained, elaborated or omitted
  – **unstructured**: no pre-determined questions, interviewer has a general area of interest but conversation develops freely
Example Questions

• Some possible questions for use in a semi-structured or structured interview regarding the introduction of automation (Randall et al 94):
  – What aspects of the work which are currently manual are not important or consequential to system purposes, and need not be supported in a computerised system?

  – What are the important manual activities which are characteristic of the system because it is manual? In other words, what activities need not be supported in an electronic system because the system will replace them?

  – What aspects of the manual system must be replicated without change in a computerised system?

  – What aspects of the work need to be supported but need not be, or cannot be, replicated in the same way in an electronic version?
Use of Verbal Protocols

• Verbal protocols are reports given by a person
  – collected either during an activity (concurrent protocol) or after (retrospective protocol)
  – usually collected alongside observational data

• Useful for:
  – collecting detailed information on many aspects of a task

• Limitations:
  – time-consuming, as protocols must be transcribed and carefully coded
  – verbalising and thinking about a task can change its nature
  – subjects may be continually revising their ideas about how they carry out an activity
Use of Verbal Protocols Continued

• **Concurrent protocols** require the subject to report what they are doing while they are doing it
  – rely on working memory and are therefore susceptible to working memory capacity limitations, interference (from other cognitive processing) and decay (forgetting)
  – may interfere with task performance (either helping or hindering)
  – focus more on physical actions

• **Retrospective protocols** require the subject to report what they did after task completion
  – require subject to remember what they did, but can be supported by video of task performance
  – better for explanations of cognitive aspects of tasks
  – more time-consuming

• Can **combine techniques** eg show concurrent protocols retrospectively
Ethnography

- Origins in anthropology; literally ‘writing the culture’
  - used in social sciences to understand the social organisation of activities, and hence work
- Aims to find the order in an activity, rather than impose a particular framework
- Users are observed doing everyday activities
  - observers immerse themselves in the user’s environment, participate in work, go to meetings, join in conversations, read documents etc
- Aims to make the implicit explicit (i.e. to identify non-prescribed elements)
  - users may be so familiar with their environment and tasks that they don’t see their importance
Ethnography Continued

• Useful for:
  – developing **detailed understanding** of work environment
  – identifying social, communication or co-ordination activities
  – understanding the way in which actions are affected by situation or context

• Limitations:
  – extremely **time consuming**
  – data can be difficult to extract
Example: Ethnographic Study of ATC

- Study reported in Randall et al 94
  - aimed at designing a user interface to the flight progress database (considering replacement of paper flight strips)
  - intention to understand how existing work practices may be supported through automation

- Carried out in en-route sector suite at London Air Traffic Control Centre

- 3 months fieldwork:
  - ethnographer aiming simply to understand the work activity by observing and questioning controllers;
  - debriefing sessions once a month where context of work was identified
Contextual Inquiry

- An approach to ethnographic study that follows an apprenticeship model
  - analyst as apprentice to user
  - analyst is an observer rather than a participant (in contrast to full ethnography)

- Uses a contextual interview
  - observation, discussion and reconstruction of past events

- Four principles:
  - context: go to the workplace
  - partnership: analyst and user collaborate in understanding work
  - interpretation: interpretation of observations should be developed in collaboration with users
  - focus: discussion between analyst and user remains focused on the system to be developed; the process is therefore typically shorter than a full ethnographic study
Human Activity Modeling

First synchronisation stage
- Gather data on human processes
- Model human activity
- Describe context model

Second synchronisation stage
- Determine system boundaries
- Determine system dependencies, goals, and rationale
- Develop use case model
- Define system-level requirements
- Use cases
- Creative design workshops
- Extended use cases
- SD and SR models

Third synchronisation stage
- Refine system dependencies, goals, and rationale
- Specify use cases
- Define and document requirements
- Use case specifications
- Use case descriptions
- SD and SR models

Fourth synchronisation stage
- Walkthrough scenarios
- Define and document requirements
- Scenarios associated with requirements
- Impact analysis
- Refine and change requirements
- System-level requirements and associated use cases

Central to HUMACT is the development of a context model to illustrate the human needs and system dependencies. This model is redefined throughout development, adapting the system to suit human needs and avoiding overcomplication in the design process.
Cross Model Checks in RESCUE

• Data at this point will not be well-organised, and will partly be in the head(s) of the analyst(s)

• Limited cross-model checking may be done by inviting analysts to:
  – validate context model
  – validate use case model
  – participate in creative design workshops
Exercise

• What sources of data would be available to your project?

• Which would you consider using, and why?

• What techniques would you use to elicit data from each of the sources?
Part 3:
Modeling Human Activity
Analysis and Modeling

- Allow requirements to **emerge** from analyst’s understanding of work domain and human activity
  - not all requirements are just ‘out there’ waiting to be collected
- Identify and include **non-prescribed components**
- **Model all possible variations** in human activity
  - don’t try to prescribe the ‘right’ sequence of actions
- **Try to link variations** to sources of variability and subjective factors
  - both inter- and intra-controller differences in performance may be due to different trade-off criteria, attitudes to risk, trust in own knowledge, trust in other controllers, belief that pilots will behave as expected etc
What’s In Activity Models

Activity models contain important concept types:

- **Human actors** describing all people involved in system
- **Resources** that are means (cognitive and non-cognitive) available to actors to achieve their goals
- **Goals** expressing desired states of the (current) system
- **Actions** (cognitive and non-cognitive) undertaken by actors to solve problems or achieve goals
- **Resource management strategies** expressing how actors achieve their goals with the resources
- **Constraints** that are the on-going environmental properties which affect decisions
- **Contextual features** - that influence decision-making
What’s In Activity Models Continued

• Goals can be grouped into hierarchies, each with a distinct high-level functional goal as its root
  – Hierarchies are drawn from the point of view of particular actors
  – Actions (and resource management strategies) are the leaves of the hierarchy
  – May be annotated to show non-prescribed or collective goals, and cognitive goals or actions
Running Example: Countdown
Activity Model - Components

Actors

– Those involved in the work of the system
– Note that development of non-prescribed goals and strategies may lead to the identification of non-prescribed actors as well

Examples from Countdown:

– Route controllers
– Bus drivers
– London Transport - Centre Comm.
Actors
Activity Model - Components Continued

Resources

- Means available to practitioners to achieve the goals and sub-goals
- can be observable (eg co-operation), or inferred (eg default knowledge or trust in the team member)
- can be cognitive or social, physical, informational, time

Examples from Countdown:

- AVL system, band 3 radio system, time card, mobile phone
- Mental maps of bus routes and possible short cuts
- Knowledge of expected bus locations, likely congestion
- Experience of types of curtailment needed
- Co-operation between on-site and off-site controllers
- Expected time to end of route
Activity Model - Components Continued

Goals

– Desired states of the system
– Range from high level functional goals, valid as long as the system remains stable, to local goals, relating to the particular task in hand
– Many goals are taken on as individual goals by particular actors; some are collective goals which can only be achieved by a number of different actors working together
– Most goals are prescribed goals, defined by the norms and regulations describing what objectives practitioners have to achieve and what standards must be followed; some are non-prescribed goals, set up by practitioners to locally adapt means they are provided with to better achieve the system level goals
Goals
Activity Model - Components Continued

Examples of Goals from Countdown:

- Manage routes effectively  
- Serve the passengers well  
- Provide bus information to potential passengers  
- Adhere to scheduled timetable  
- Monitor bus locations on the AVL system  
- Liaise with off-site route controllers  
- Look for buses packing up together  
- Try to maintain headway  
- Decide on route changes  
- Slow down a bus  
- Curtail a bus journey  
- Take a bus on an ‘out-of-service’ short cut to catch up  

- Look for lost property in all buses on a particular route  
- Find out if someone is a QSI  

(high level)  
(local)  
(collective)  
(non-prescribed)
Non-prescribed goals
Activity Model - Components Continued

Actions

– Activities engaged in to achieve a goal
– Might not directly achieve the goal but enable this, for example by deciding to wait to gain further information

Examples from Countdown:

– See how an individual bus is doing
– Compare estimated time with scheduled time
– Tell off-site controller to see how a bus is when it arrives
– Tell a bus to slow down
– Look for next turnaround point
– Tell a bus to curtail its journey
– Transfer passengers to another bus
Actions
Activity Model - Components Continued

Resource Management Strategies

– Can be seen as a special kind of action
– How practitioners cope individually and collectively with resource limitations, e.g. limited time, trust in default knowledge, attention limits

Examples from Countdown:

– Do a group call to all drivers with route information to save time on the radio
Resource Management Strategies
Activity Model - Components Continued

Constraints

– On-going properties of the environment that need to be taken into account when deciding about an action

Examples from Countdown:

– Bad quality radio links due to location (e.g., high buildings)
– Volume of call traffic from drivers
– Loss of radio communication due to going off route
– Language problems, difficulties understanding drivers’ accents
Constraints
Activity Model - Components Continued

Contextual features
  – Situational factors affecting people’s decision making

Examples from Countdown:
  – Traffic jams, road works
  – Accidents
  – Bus mechanical failure
  – Driver stress or emotion due to code red situation
  – Unusual weather conditions
  – Passenger or driver illness
  – Dangerous passengers
  – Knowledge about delays on a particular route on a particular day
Contextual Features
Examples from ATM

• A small exercise was carried out using ‘real’ scenarios to elicit controller protocols
• Data from individual protocols was combined to create an activity model relating to the activity of ‘monitoring air traffic’
Example Data from ATM Scenarios

- **Actor:** controller 5
- **Triggering problem:** Catch on SLR3519 and BRA935
- **Resources:** Co-ordination
- **Goals:**
  - Negotiate with next sector who solves the catch up (*non-prescribed*)
  - Verify aircraft capabilities to climb higher
- **Actions:** Co-ordinate radar transfer, descend BRA, climbing one of the two
- **Resource management strategies:** Negotiate load sharing
- **Constraints:**
  - Destination (BRA)
  - Aircraft performance
Example Data Continued

- **Actor**: controller 3
- **Triggering problem**: SAB874, SAB888, same exiting point
- **Resources**: Time to closest point (enough for delegation)
- **Goals**:
  - Do not deal with the problem *or*
  - Deal with the problem
- **Actions**: Assign low altitude to climbing aircraft
- **Resource management strategies**:
  - Delegate solution to next sector
  - Eliminate uncertainties asap
Example Activity Model: Monitoring Air Traffic

Actors
– Radar controller, planner controller, controllers from other sectors and centres, cockpit

Resources (prescribed and non-prescribed)
– Default knowledge, co-operation, co-ordination, communication, procedures, tools, time, pilot capabilities/states/intentions
Example Activity Model Continued

**High-level functional goals**
- Monitor the traffic, maintain aircraft conformance, anticipate future conflicts, anticipate opportunities for traffic improvement and better use of the airspace, find solutions that satisfy the highest number of constraints

**Local (prescribed and non-prescribed) goals**
- Confirm conflicts between aircraft, allocate conflict solution, detect conflict in the next sector, resolve conflict, verify aircraft capabilities

**Individual goals (non-prescribed)**
- Maintain a good understanding of the situation, keep workload at an acceptable level, do not forget anything important
Example Activity Model Continued

Actions

– Co-ordination of flight level and heading, co-ordination of radar transfer, flight level assignment, heading assignment, communication of information to the next sector

Resource management strategies

– Workload regulation, risk assessment (eg, probability of making a wrong anticipation), elimination of uncertainties, co-operation and communication, negotiation of load sharing (eg delegation of solution to next sector)
Example Activity Model Continued

Constraints

- Aircraft type/capabilities/status, letters of agreement (LoAs), rate of climb/descent, preferred flight level/route, flight origin and destination

Contextual features

- Traffic density, aircraft exiting on the same beacon, conflict originating in the present sector
Human Activity Modeling
Cross-Model Checks in RESCUE

All components of the activity model may now be used in other RESCUE sub-processes, as follows:
Goals used in ... 

**First synchronisation stage**
- Determine system boundaries
- Creative design workshops

**Second synchronisation stage**
- Determine system dependencies, goals and rationale
- Extended use cases
- Use cases
- Use case description
- System-level requirements and associated use cases

**Third synchronisation stage**
- Refine system dependencies, goals and rationale
- Refined i* SD and SR models
- Use case specifications
- Use cases associated with requirements

**Fourth synchronisation stage**
- Specify use cases
- Define and document requirements
- Use case specifications
- Define and document requirements
- Scenarios associated with requirements
- Walkthrough scenarios
- Define and document requirements
- Refine and change requirements
- Impact analysis
Actors used in ...

**First synchronisation stage**
- Determine system boundaries
- Creative design workshops
- Extended use cases
- Use cases
- Use case diagram and use case summaries
- Define and document requirements
- System-level requirements
- System-level requirements in VOLERE shell

**Second synchronisation stage**
- Determine system dependencies, goals and rationale
- Design work shops
- Describe use cases
- Use cases
- Use case descriptions
- System-level requirements and associated use cases
- Define and document requirements

**Third synchronisation stage**
- Refine system dependencies, goals and rationale
- Refined *SD and SR models
- Specify use cases
- Use case specifications
- Use cases associated with requirements
- Define and document requirements

**Fourth synchronisation stage**
- Walkthrough scenarios
- Scenarios associated with requirements
- Define and document requirements
- Impact analysis
- Refine change requirements
Resources used in ...

First synchronisation stage
- Determine system boundaries
- Develop use case model
- Define system-level requirements
- Creative design workshops
- Use cases
- Use case diagram and use case summaries
- System-level requirements in VOLERE shell
- SD and SR models
- Context model
- Use case descriptions
- System-level requirements and associated use cases

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Resource mgmt strategies used in...

First synchronisation stage
- Determine system boundaries
- Determine system dependencies, goals and rationale
- Creative design workshops

Second synchronisation stage
- Use cases
- Requirements
- Define system-level requirements
- SD and SR models

Third synchronisation stage
- Refine system dependencies, goals and rationale
- Use case descriptions
- Specify use cases
- Define and document requirements
- Refined SD and SR models

Fourth synchronisation stage
- Use case specifications
- Define and document requirements
- Use cases associated with requirements
- Scenarios associated with requirements

Fourth synchronisation stage
- Walkthrough scenarios
- Define and document requirements
- Impact analysis
- Refine and change requirements
Constraints used in ...
Actions used in ...
**First synchronisation stage**

- Determine system boundaries
- Creative design workshops
- Extended use cases
- i* SD and SR models

**Second synchronisation stage**

- Determine system dependencies, goals and rationale
- Use cases
- Descriptions of use cases
- System-level requirements

**Third synchronisation stage**

- Refine system dependencies, goals and rationale
- Use case specifications
- Use cases associated with requirements
- Extended use cases
- Refined i* SD and SR models

**Fourth synchronisation stage**

- Specify use cases
- Define and document requirements
- Use cases associated with requirements
- Walkthrough scenarios
- Define and document requirements
- Scenarios associated with requirements
- Impact analysis
- Refine and change requirements
Exercise

What equipment will you need?

What questions, prompts, scripts etc?

… to ensure you will get full coverage of all activity model components?
Part 4:
Summary and Conclusions
Summary and Conclusions

• An activity model should provide a useful repository of information and understanding about the current socio-technical system which can inform the specification of the future system.

• This is a ‘light-weight’ approach to incorporating human factors input into the requirements process.
Summary and Conclusions Continued

• Parts of the model may be represented more formally, for example:
  – using task analysis to analyse and model goals and actions may help in understanding boundaries and requirements for a future system
  – cognitive task analysis may be useful in checking limitations on cognitive resources will not be exceeded in future system

• But in general, do not get bogged down in unnecessary modeling: use more formal models locally, to address particular problems