

# Human Behaviour Models for Activity Recognition

## Requirements Analysis

## 1 Introduction

The document describes three problem domains for human behaviour modelling – 3-person meeting, kitchen task assessment, and an office scenario. The aim of the questionnaire is to identify and validate the requirements for modelling these domains, which later will be used for choosing a suitable modelling formalism.

## 2 Requirements analysis

### 2.1 Domain understanding

#### 2.1.1 3-Person meeting

A meeting takes place in the SmartLab. There are 3 participants that are in the room during the meeting, each of them is supposed to make a presentation with the option of a discussion after the end of the third presentation. At the beginning of the meeting the 3 participants enter the room, two of them go to their respective seats and one goes to the stage area in order to prepare his presentation. After the first presentation is over, the presenter goes to his respective seat, while the second presenter starts his presentation. The same procedure is repeated for the third participant and after the last presentation, the participants have the option to make a short discussion regarding the presentations. The order in which the presentations are made is arbitrary and could be performed in any order, namely

- (user A, user B, user C)
- (user A, user C, user B)
- (user B, user A, user C)
- (user B, user C, user A)
- (user C, user A, user B)
- (user C, user B, user A).

After the last presentation, or after the discussion respectively, the participants get up from their seats and leave the room. The goal of the participants is that all of them have presented, optionally discussed the presentations, and finally left the room.

There are several locations defined in the room: three seats, a stage, and a door area. Manipulated objects are not being observed.

The objective of the system is to recognise the users' current actions and to discover if they have reached their goal at the end.

The datasets used to describe this use case are 20 staged small meetings that lasted about 3 min. each and included a discussion, and one non-staged long meeting that did not include a discussion and lasted for about 50 min..

#### 2.1.2 Kitchen task assessment

A person is cooking a carrot (however funny it may sound) in the SmartLab, where the lab is rearranged so that it can provide the needed appliances for such task. The person starts by washing his hands, then cutting the carrot, putting it into the pot and cooking it. Later after the meal is ready, the person serves it in a plate, puts water in a glass, and sits on the table to have a lunch. Finally, after the person has eaten and drunk water, he stands up, goes to the sink and washes his utensils. There are generally the following experiment stages that should be executed in the same order.

- wash hands
- cut carrot
- cook carrot

- serve meal
- eat
- wash utensils

However, the intermediate actions that take place (such as fill plate, fill glass, move, etc.) can be executed in any causally correct order. Although the task at hand, namely cooking, is staged, the behaviour of the participants while achieving their goal was left to themselves. This resulted in different execution paths leading to the goal state.

The locations during the experiment were sink, counter and table, which were locations that could be reached only by walking from one place to another. Additionally, there were fixed locations, or places, which from a certain locations can be reached only by moving the hand. The places were cupboard and oven, which could be reached from the counter. Furthermore, different objects with varying functions and properties were used: cutting board, pot, plate, glass, bottle, knife, spoon, sponge, and the additional water and carrot objects.

The objective of the system is to recognise the users behaviour.

The datasets used to describe the use case were 6 cooking tasks that lasted around 7 min. each.

### 2.1.3 Office scenario

This is an office scenario where a varying number of users enter an office room that contains a printer and a coffee machine. The experiment is performed in the SmartLab. The objective is to print some documents and each of the users to get a cup of coffee. The behaviour of the users is non-synchronized and everyone is separately choosing their actions. To make the problem more complicated, it is possible that the water or the ground coffee in the coffee machine are not enough, and in such case the coffee machine has to be refilled with ground coffee and water before making coffee. Additionally, it is possible that there is no paper in the printer, or that paper is stuck inside and the printer has to be repaired.

The goal of the users is to have their documents printed and to get coffee. The order in which the actions are executed, or the persons who perform the different tasks is arbitrary. Additionally, only the locations in the room are observed but not the actual users or the objects that they manipulate. The only thing the sensors tell us is that there is somebody at a given location.

The locations during the experiment are the door, the printer, the paper stack, the coffee machine, the water tap and the coffee jar. The objects available are paper for the printer, water and ground coffee.

The objective of the system is to recognise what action is being executed in the moment and who is involved in executing it.

The datasets used to describe the use case are 4 one-person scenarios, one two-person scenario and one three-person scenario. The duration of the different datasets is between 50 and 200 time steps.

## 2.2 Requirements collection and classification

The IEEE 610.12-1990 standard [4] defines requirement in the following way.

- (1) *A condition or capability needed by a user to solve a problem or achieve an objective.*
- (2) *A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed documents.*
- (3) *A documented representation of a condition or capability as in (1) or (2).*

In our case a requirement is a condition or capability needed by a model designer to solve a modelling problem or to achieve an objective. This condition or capability should be possessed by the modelling formalism used for solving the problem. For example, for modelling the behaviour of people acting in parallel, one needs a modelling formalism that is able to represent parallel actions execution.

In a similar manner, analysing the three problem domains described in the previous section, the requirements for modelling human behaviour for activity recognition were identified. Later their actual existence in the datasets was validated from the experiments ground truth - namely the annotation - by calculating the number of occurrences of actions with a given requirement in a problem. These requirements are based on the behaviour the experiments' participants exhibited and 14 requirements from this kind were identified (sequences, composition, parallelism, interleaving actions, repetition, choice, enabling, disabling, priority, independence, dependence, synchronization, suspend, resume). Additionally, there are some requirements based on the uncertainty of partially observing the world - 3 in total (probabilistic durations, observation model, unobserved actions), and also 2 based on the application (activity recognition, error detection). In Section 3 every one of the 19 requirements is specified separately and a number of questions are asked in regard to it, in order to identify if the requirement is correctly specified and if it is needed at all.

## 2.3 Requirements validation

Based on the software requirements specification (SRS) semantic properties described in [2] and the model requirements properties defined in [1], the semantic properties of a model requirement were defined. Namely, each model requirement specification (MRS) should be:

- **verifiable:** represented by the accuracy with which the requirement can be transformed from higher levels of abstraction into its current form. i.e. how accurately a given abstract action requirement can be mapped to the concrete requirement in the described problems. *Example:* Based on the requirement specification, how accurately the abstract requirement "sequences" can be mapped to the concrete instances of sequences in the 3-Person meeting problem?
- **valid:** represented by the accuracy with which the requirement represents the real need, i.e. does the requirement accurately represents the needs of the described problem. *Example:* Does the requirement for parallel actions represents an actual need for modelling such actions in the kitchen task assessment problem?
- **clear:** represented by the degree to which the requirement is unambiguous and understandable, i.e. do you have doubts about the requirement's meaning. *Example:* How clear is the meaning and specification of the requirement "sequences" to you?
- **complete:** represented by the degree to which all parts of a requirement are specified without missing information, i.e. is there something missing in the requirement's specification. *Example:* Is there some information missing in the specification of the requirement for sequences?
- **consistent:** represented by the degree to which the requirements are specified using uniform notation, terminology, and symbology, and any one requirement does not conflict with any other. *Example:* Is the requirement for sequences consistent with the rest of the requirements' specifications?
- **feasible:** represented by the degree of difficulty of implementing a single requirement and simultaneously meeting competing requirements, i.e. can an action with a given requirement be easily modelled without contradicting other requirements. *Example:* How easy it is to implement the requirement "sequences" without contradicting the requirement for parallel actions execution?
- **testable:** represented by the degree to which the requirements can easily be tested. A testable requirement is one that is specified in such a way that a pass/fail criteria can be derived from its specification. *Example:* Based on the requirement specification, do you think that the requirement's implementation of "sequences" will be possible?
- **traceable:** represented by the degree to which the requirements related to a particular requirement can easily be found. *Example:* How easy is it to find the requirements that are related to the requirement for interleaving actions?

## 2.4 Glossary

Throughout the requirements specifications several terms were repeatedly used. Below is their informal definition.

- **state of the world:** the global ground truth for all environmental variables at a given time. In other words the concrete instances of all varying elements of the environment at some specific time.
- **preconditions:** the state of the world that has to be true in order for an action to be executed.
- **effects:** the state of the world after a given action was executed.

### 3 Questions

#### 3.1 General questions part I

*What is your age?*

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*What kind of academic degree do you have?*

☐ Abitur   ☐ Bachelor   ☐ Master   ☐ Diplom   ☐ Doctor   ☐ Professor   ☐ Other:.....

*Have you ever modelled human (user) behaviour with any kind of modelling formalism?*

- ☐ yes, I often build models
- ☐ yes, I built several models
- ☐ yes, I built a complex model once
- ☐ yes, I built a simple model once
- ☐ no, I have never modelled human behaviour before

*In which field of computer science do you work?*

- ☐ activity recognition
- ☐ modelling and simulation
- ☐ visual computing
- ☐ software engineering
- ☐ student in computer science
- ☐ other:.....

*If relevant, with what kind of modelling formalisms have you worked before?*

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*List two modelling formalisms with which you think the 3 problems from Section 2.1 could be modelled?*

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## 3.2 Sequences

**specification:** the requirement allows modelling actions that are executed in a sequential order. For that, at a given time at least two actions should exist where the preconditions of at least one of the actions are satisfied, and those of the second are either satisfied or will be after the execution of the first action. Additionally, there should not be any constraints forbidding the sequential actions' execution.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example given by you? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.3 Composition

**specification:** allows expressing actions composed of other more fine-grained actions. For that, a composite action should exist that consists of at least two actions, which can be executed either in parallel or sequentially.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

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*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.4 Parallelism

**specification:** allows executing actions in parallel. For that, at a given time at least two actions should exist and both actions preconditions should be satisfied. Additionally, there should not possess constraints forbidding the actions' execution in parallel.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.5 Interleaving actions

**specification:** allows expressing actions that interleave each other. For that, at least two actions should exist and parts of the first can be executed sequentially in between parts of the second, until the actions are completed and their effects hold.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant



### 3.6 Repetition

**specification:** allows repeating an action until a certain condition is met. For that, at a given time an action should exist which preconditions hold and that after being executed changes the state of the world to one where the preconditions still hold. The action can then be repeatedly executed until a certain state of the world is reached.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.7 Choice

**specification:** allows the option of choosing between several actions when the action's preconditions hold. for their execution are met. For that, at a given time at least two actions should exist which preconditions are satisfied but at the given time only sequential execution is allowed. Then one of the actions is executed.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.8 Enabling

**specification:** enables the execution of a given action. For that, an action should exist which execution satisfies the preconditions of a given action (or a set of actions) that previously could not be executed.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

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☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.9 Disabling

**specification:** disables the possibility of executing a given action. For that, exists an action that after being executed dissatisfies the preconditions of a given action (or a set of actions) that could previously be executed.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.10 Priority

**specification:** allows preferring an action to other actions when the preconditions are met. For that, at a given time at least two actions should exist with priority values assigned to each of them, and with preconditions that are satisfied but at the given time only sequential execution is allowed. Then the action with the higher priority value is chosen.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.11 Independence

**specification:** allows the execution of an action to be independent of the effects of other actions. For that, at a given time an action should exist which preconditions are satisfied and it can be executed regardless of the changes in the state of the world done by the execution of other actions.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

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*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.12 Dependence

**specification:** allows the execution of an action to be dependent on the effects caused by other actions. For that, at a given time an action should exist which preconditions being satisfied depends on the execution of a given action or set of actions.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example given by you? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.13 Synchronization

**specification:** allows synchronizing several actions with each other. For that, at a given time an action should exist which execution synchronizes the execution of at least two other actions.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example given by you? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant



### 3.14 Suspend

**specification:** allows suspending an action before continuing it again at a later point in time. For that, at a given time an action should exist which by being executed suspends the execution of a given action before its effects were satisfied.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example given by you? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.15 Resume

**specification:** allows the resuming of an action after it was previously suspended. For that, at a given time an action should exist which by being executed resumes the execution of a given action that was previously suspended.

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*Give an example from one of the three problems in Section 2.1 that describes behaviour possessing this requirement.*

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example you gave?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example given by you? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.16 Probabilistic durations

**specification:** allows expressing actions' durations in terms of probabilistic distribution, i.e. describes what is the probability of the action continuing to be executed in the next time step. For that, an action should exist that lasts more than one time step.

*example:* in the 3-person meeting scenario the action (presentA) has a duration that lasts 500 time steps and can be expressed with a gaussian normal duration distribution.

*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example above?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example above? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.17 Observation model

**specification:** allows expressing the connection between high-level model states and observation data, i.e. what sensor reading is associated with which states in the model. For that, at a given time the model provides the probability of a certain observation given a model state.

*example:* in the 3-person meeting scenario the observation model defines that at coordinates {352, 658, 100} (in cm) observed by UbiSense the person is (at seatA) with probability of 90%

*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example above?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example above? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.18 Unobserved actions

**specification:** allows modelling action that were executed by the user but not observed from the sensors due to sensor granularity or unreliability. For that, an action should exist that was never observed but which execution is needed for satisfying preconditions of a given observed action.

*example:* in the 3-person meeting scenario the action (preparePresentationA) is not observed but the action is necessary for executing the action (presentA) and for synchronizing it with (listenB) and (listenC).

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example above?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example above? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.19 Activity recognition

**specification:** the model allows inferring actions based on a set of observations. For that a set of observations should exist that support at least one of the model hypotheses (execution sequences).

*example:* in the kitchen task assessment problem at time  $t_1$  observation  $o_1$  supports the action (wash hands) with probability of 90%, (move) with probability of 5 %, and (wait) with probability of 5 %, thus the model infers that the executed action is (wash hands)

*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example above?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example above? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

### 3.20 Error detection

**specification:** allows detecting causal user errors in the actions' execution. For that at a given time should exist an action which preconditions are not satisfied, but the observations at the given time support the hypothesis that the action is being executed.

*example:* the observations support the hypothesis that the user executes (cook) although the constraints are not satisfied because the action (turnOn stove) was never executed.

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*Is the requirement verifiable? How accurately does the requirement's specification represent the concrete example above?*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement valid? How accurately does the requirement's specification represent the actual requirement needed in the example above? (Is that really what you need?)*

☐ very accurately   ☐ accurately   ☐ not very accurately   ☐ inaccurately   ☐ very inaccurately

*Is the requirement clear? To what degree is the requirement unambiguous and understandable?*

☐ very clear   ☐ clear   ☐ relatively clear   ☐ unclear   ☐ very unclear

*Is the requirement complete? Is there some missing information in the requirement's specification?*

☐ nothing missing   ☐ almost nothing   ☐ some   ☐ most missing   ☐ everything missing

*If relevant, what information is missing in the requirement's specification?*

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*Is the requirement feasible? How easy can the requirement be implemented without contradicting competing requirements?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*Is the requirement testable? Do you think the implementation of the requirement will be possible based on its specification?*

☐ highly likely   ☐ likely   ☐ plausible   ☐ unlikely   ☐ highly unlikely

*Is the requirement traceable? Can you easily identify requirements related to this requirement?*

☐ very easy   ☐ easy   ☐ moderate   ☐ difficult   ☐ very difficult

*How important is this requirement for solving the three modelling problems?*

☐ very important   ☐ important   ☐ not important   ☐ optional   ☐ irrelevant

*For each requirement in the table below, identify two requirements that are related to it and make a tick where the requirement crosses with them.*

[illegible]



*For each requirement is the requirement consistent? To what degree the requirement is specified using uniform notation, terminology, and symbology compared to the other requirements?*

Requirement	very consistent	consistent	relatively consistent	inconsistent	very inconsistent
sequences					
composition					
parallelism					
interleaving activities					
repetition					
choice					
enabling					
disabling					
priority					
independence					
dependence					
synchronization					
suspend					
resume					
probabilistic durations					
observation model					
unobserved actions					
activity recognition					
error detection					

*The list with requirements above should contain all requirements needed to describe the problems in Section 2.1. Do you think that the list of requirements is complete?*

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*If not, which requirements are missing?*

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## References

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