**Supplementary Material**

**A.** **RESULTS FROM LITERATURE REVIEW**

## System Requirements Examination

An ideal assistive technology device (ATD) for supporting outdoor activities of people with mild dementia should detect and support the user goals and intentions. The notion of such assistive system complies with the concept of situation-aware mobile assistance proposed by Chavez et al. [1]. Such system should be able to recognize the user tasks, to reason about the user’s physical environment, the user’s current state, his preferences, and goals. Going a step further, Teipel et al. [2] discuss that an ATD should flexibly and automatically adapt to changes in user’s plans and goals. It should also detect deviations from the typical behavior in the context of actual extrinsic factors (e.g., traffic situation, opening hours, weather conditions), actual intrinsic factors (e.g., psychophysiological stress, perceptual, cognitive, motor, and coping abilities), and long-term intrinsic factors (favorite means of transportation, social activity routines) [2]. Below we discuss in some more detail the factors that influence the system requirements.

*Intrinsic factors influencing mobility*

An important aspect of navigation planning is the person’s goal. Acting in a goal-directed way in dynamic environments requires decisions based on an awareness of relevant situational aspects and knowledge about the likely results of certain actions. People with dementia experience problems in performing structured, goal-directed activities of daily living. This condition holds particularly for elderly persons with dementing disorders like Alzheimer’s disease (AD), who progressively lose the ability to perform even very basic activities of daily living [3]. This indicates that for an assistive system to be able to accurately support the outdoor mobility of people with dementia, it has to be aware of their **goal**. In that manner, the system can compensate the missing resources needed for planning.

Another ability that is affected by dementia is the navigational skills and performance of spatial tasks. Lithfous et al. [4] provide a comprehensive overview of navigational skills and a comparison of performance between healthy aging and prodromal stages of AD. While performance in spatial tasks generally deteriorates with age, people with AD dementia show more severe impairments. This development already starts in the prodromal stage of mild cognitive impairment. Affected skills range from perceptual abilities over spatial learning to map-building abilities. On the perceptual layer, people with AD do not perceive their own motion as accurate as healthy controls on the basis of visual features. Keeping track of direction and distance moved is prone to errors. This indicates that an ATD has to be aware of the person’s spatial **motion** to be able to detect problems in spatial navigation.

Furthermore, AD as the most common cause of dementia, involves explicit memory and spatial orientation, both with direct effect on navigation ability [5]. This implies that an ATD should be able to assess the **cognitive state** of the person and detect impairments of episodic memory. It should also be able to reason about the causes of **disorientation** (such as missing information due to impaired memory versus primary visio-spatial impairment) [6] and to provide the corresponding cue (such as information on the goal versus direct directional cue) to the person with dementia.

Moreover, decreased mobility is associated with higher risk of physiological problems such as cardiovascular disease [7]. It is then possible that the person’s mobility is affected by his **physiological state** such as blood pressure, heart rate, etc. Even more, disorientation can increase the stress level of a person, changing his/her physiological state [8]. For that reason, different works consider the usage of sensors that measure such physiological signals to reason about the physiological and emotional state of persons with dementia and to integrate this information into an intervention strategy [9].

Recognizing landmarks is also an affected skill and reorientation therefore problematic. Navigating in known environments becomes a challenge, because the access to cognitive representations of spatial layouts is affected. Allocentric representations, referred to as *cognitive maps*, set spatial **objects** in relation to certain landmarks. This dynamic information structure enables younger people to recognize shortcuts, replan routes if a way appears to be impassable, or to head toward not directly visible targets. This skill is impaired for elderly people, but heavily compromised in AD patients. The egocentric pendant recognizes environmental objects in relation to the own position and plays a major role in following well-known paths. Perceived landmarks are mapped to learned responses, e.g., *before the post-office turn left*. An increase in the problems regarding this form of wayfinding causes increasing difficulties, even when navigating along known routes [4]. This indicates that an ATD should be able to provide the missing information about the environment and its landscape. The topological and environment information, however, is represented by extrinsic elements that influence the intrinsic way-finding ability of the person. Below we discuss these factors.

*Extrinsic factors influencing mobility*

The **area** the person is located with its specific landmarks and obstacles, and the **local conditions** such as weather conditions, opening hours, or traffic situation [2] influence the automated detection of disorientation and ensuing intervention strategies. Therefore, the system has to be aware of the person’s **location** [2]. Furthermore, as the ATD aims at providing assistance during outdoor mobility, it has to be aware of the **transportation mode** the person chooses and the corresponding implications it has on the user’s behavior (such as time plan for public transportation, active decision making when using a car, ticket costs, alternative routes, etc.) [10]. Weather and street conditions, construction work, time of day with resulting illumination conditions and number of people on the street (lunch break versus office hours), obstacles and objects in the environment are important external factors that need to be integrated into the situation model.

*Long-term intrinsic factors influencing mobility*

As Skillen et al. [11] point out, humans have different lifestyles and their needs differ. For that reason, these aspects need to be modeled. They explain that *“As a result, user profile modeling is required to achieve the desired level of personalized service that has the ability to adapt to a particular user”* [11]. This indicates that people with dementia should be assisted based on their preferences with respect to outdoor activities, such as preferred **routes**, preferences regarding **transportation means**, typical **social activities**, or preferences based on their **social background**. For example, interviewed about their perception of accessibility to public space, people with dementia reported, in a study of Brorsson et al. [12], an altered use of public space - a limitation to familiar activities and environments. This aligns with the observation of decreasing outdoor mobility [13, 14] and social activity [15, 16] in relation to progressive cognitive decline.

Furthermore, **medical history** is important factor for interpreting user’s behavior and for deciding on appropriate intervention strategy. As Skillen et al. explain, the user capabilities such as hearing or vision can enable the correct form of assistance to be provided [11].

Finally, one essential long-term intrinsic factor is the user’s **affinity to technology**. As Teipel et al. [2] point out, in order for the ATD to be feasible, we have to take into account the user’s capabilities to cope with the system as well as the user’s potential to learn novel routines.

*Interaction with the environment in persons with dementia*

Apart from the intrinsic and extrinsic factors affecting mobility, an important aspect of any ATD is the interaction of the user with the environment. This interaction is expressed in the **actions** the user is executing, the **manipulation/interaction** with objects in the environment, and any **communication** with persons in the environment. These three types of interaction come from the purpose of any ATD: namely, it has to assist the user based on the recognized activities and inferred goals [17]. To recognize the activities, the system has to be aware of the possible actions that can be executed in the environment [17, 18]. It has to also be aware of the interaction of the user with other users as this can change the observed behavior, for example, towards following a common goal [19], or receiving instructions for executing tasks [20]. Finally, the system has to be aware of the objects the person is manipulating or interacting with, because the same action can have a different context depending on the object it is executed on[[1]](#footnote-1) [21, 22].

The interaction with the environment also involves animate and inanimate objects in the environment that need to be modeled.

For the ATD to be able to reason about all factors discussed above and how they affect the user’s behavior, the factors have to be integrated into the situation model. In the next section, we look into existing ontologies and classification systems and discuss whether they incorporate these concepts.

## Review of Existing Ontologies

Our search in the ontology repositories showed only general disease-related concepts. We, however, could not find any of the strings that relate to our use case[[2]](#footnote-2).

For that reason, we concentrated on searching the literature for descriptions of existing ontologies. Below we shortly discuss our findings.

*Ontologies describing behavior of people with dementia*

With respect to behavior of people with dementia, most of the reviewed ontologies and classification systems provide description of the user activities, the location, and cognitive state. While most of the reviewed papers concentrate on the actual extrinsic and intrinsic factors, Skillen et al. [23] provide an ontology that concentrates on the long-term intrinsic factors. Almost all of the ontologies and classification systems describing behavior of people with dementia incorporate the user’s cognitive state, and more precisely the type of behavioral incoherence during task execution. Most works use the following concepts: initialization of the task, organization of the necessary tools for the task execution, sequence of execution of the steps in the task, judgment of potential errors and safety, and the realization of the task completion [24-26]. In difference to the above works, Bettcher et al. [27] use the types of errors in behavior proposed in the Naturalistic Action Test [28]. These are errors when a task step is performed incorrectly (i.e., sequence error, substitution, etc.), when an off-task step is performed (i.e., action addition), and when a step is never executed (i.e., omission). It can, however, be seen that these types of errors can also be matched with one of the above six categories. All works addressing the behavior of people with dementia target indoor home settings as the application domain. So far, no ontology has concentrated on the behavior of people with dementia during outdoor mobility.

*Mobility ontologies*

The ontologies and classification systems addressing mobility usually provide information about the type of area (urban or rural), the means of transportation, and the types of locations during mobility (e.g., street, crossing, building, etc.). Most of them, however, do not consider the fact that the person performing outdoor mobility might attempt communication in order to request assistance. That is especially true for people with dementia, who might get disoriented during their outdoor activities. Schlenoff et al. [29] consider this problem in the case where the agent is not a person, but rather a robot. They propose robot ontology for urban search and rescue. There, they propose two types of communication: the "secure” communication that involves remote communication (e.g., over a communication device like a cell phone); and the "line-of-sight” communication that involves communication within the line of sight (i.e., the person communicates with somebody nearby and no communication devices are needed). In our problem domain, we are also interested in these two types of communication as the person can either attempt to communicate with other persons at his locations, or he/she can attempt a remote communication (e.g., via a mobile phone).

*Motion ontologies*

The motion ontologies usually consider a fine-grained action such as “grab”, “throw”, or the execution of a specific dance step. They also describe the motions from which these fine-grained activities are built. In contrast to the ontology representing the Benesh notation [30] that allows specifying, for example, the exact position and movement of each body part, or the model of the whole skeleton using the approach described in [31], we are not interested in this level of detail. To detect disorientation of persons suffering from dementia, it might be enough to model the direction of the human movement and the rotation of the human body.

*Activity recognition ontologies*

Regarding the ontologies for activity recognition, most of them describe the user activities and the goal that the person is following. They also incorporate the user location as it contains important context information about the current situation (e.g., being in the kitchen yields different set of possible activities than being in the bathroom). Some of the ontologies for activity recognition also describe body motion as the sensors with which the activity is observed usually detects low-level movements instead of high-level activities[[3]](#footnote-3). Many works also rely on a catalogue of preferred behavior sequences. They, however, do not rely on more detailed long-term intrinsic factors. Apart from that, the reviewed activity recognition ontologies concentrate on indoor activities. On the other hand, there is not much research on activity recognition ontologies for outdoor activities, especially concerning the problems of people with cognitive impairments.

# B. RESULTS FROM MOBILITY STUDY

**Placement of Sensors**

Motion sensors were placed at the left ankle, the chest, and the left wrist using movisens sensors. The devices recorded acceleration in three orthogonal directions with a resolution of 12 Bit at 64 Hz sampling rate. A Move II sensor was attached to the left ankle. An ecgMove sensor, which can additionally record the electrocardiogram, was fastened near the sternum using two adhesive electrodes. An edaMove was attached to the left wrist. The sensor was also equipped with two electrodes to measure the electrodermal-activity.

**Guided Walk**

The walk to the tram station lasted 15.37 minutes on average, while the way back lasted 22.26 minutes on average. The collected sensor observations consisted of 0.599 Gb data, while the video log consisted of 18.625 Gb data and had an overall duration of 6.93 h.

During this observation, the psychologist noted that the exhibited behavioral errors conform with those proposed in [24]: initialization, organization, sequence of execution, judgment, and realization errors. Furthermore, during disorientation, two types of challenging behavior were observed. The first was rational behavior (i.e., searching for information). There the experiment participants tried to reason about the spatial and topological layout in order to orient themselves. They also attempted communication with the psychologist to obtain the missing information. The second type of challenging behavior was irrational one. It comprised of wandering during disorientation.

Based on these observations, four behaviors associated with disorientation during outdoor mobility were identified. These are *spatial reasoning*, which indicated that the person attempted to orient himself/herself based on the surrounding environment. The second action is *topological reasoning*, which is exhibited when the person tries to orient mainly based on street signs/landmarks. The third action is *communication*, which indicates that the person attempts to communicate with somebody in order to receive the missing information. The fourth action is *wandering*, which indicates that the person is acting irrationally without attempting to obtain the missing information[[4]](#footnote-4). The rest of the exhibited behavior can be described as *normal* as it does not indicate disorientation, thus, there is no need for assistance.

Apart from these actions, the normal behavior also consisted of different mobility-related actions such as *crossing a street*, *waiting for the traffic light*, *walking,* etc.

**Long-Term Assessment**

During the long-term mobility, 11.284 Gb of sensor data was recorded. Apart from the sensor data, 414 entries from the mobility diary were collected. An initial analysis of the mobility diary and the GPS data showed the following goals during mobility: going out for a walk, visiting the doctor, visiting friends. It was also observed that the participants often performed outdoor mobility with an escort, both with a human and a dog.

Furthermore, different types of transportation were identified. These included a public transportation (bus, train, tram), private car, bicycle, or walking on foot. It was also observed that the participants also took walks in rural areas (e.g., in the field) and did not always stay in the urban area.

# C. CONCEPTS IDENTIFIED IN THE MODEL

## Interaction Unit Analysis

During the interaction unit analysis, seven normal action classes were identified. Four of them were identified during the guided walk. These are *walk*, *evade obstacle*, *cross a street*, and *wait*. The remaining three actions were identified from the initial analysis of the long-term mobility study and from the interviews. These are *drive*, *take public transportation*, and *enter a building*. For each of the normal actions, the corresponding errors in behavior and their causes were identified.

Similarly, the same procedure was performed for the interaction with the environment and the communication with people in the environment. Examples of identified actions that show physical interaction with the environment are *buying a ticket*, *opening a door*, *touching a person* etc. Examples of visual interaction are *reading a sign* and *looking for landmarks*. Examples of identified communication actions are *asking a person for directions* or *calling on the phone*. For each of these actions, corresponding compensatory behavior was identified and the possible causes listed. The result of this analysis was the basis for the relations between the different concepts in the ontology.

## Identified Concepts and Relationships

The identified concepts were categorized in a hierarchical structure where the uppermost categories are those identified from the system requirements examination, while the middle and bottom layers are based on the literature review, the interviews, and the interaction unit analysis. For each of the identified concepts, the corresponding sources were given. These can be either from the literature, the mobility study, or the IUA.

We also modeled the user as a concept (i.e., “Person”). This is due to the fact that the user plays a central role in the assistance system and the system needs the knowledge of how he is related to the concepts in the knowledge base. This approach of modeling the person as a concept is also applied to the situation models in [22, 33]. In other works such as [17, 34], the user is modeled as a special concept that represents the protagonist (or agent) executing the actions in the environment. The definitions of the concepts can be found in Supplementary Table 1.

Furthermore, 11 relation types were identified between the concepts. We divide these relations into 4 categories:

* relations describing the abstraction hierarchy of concepts. In an assistance system, these relations are used to abstract or specialize the retrieved from the situation model knowledge.
  + *is a* indicates that the given concept is a sub-concept of another concept. For example, *motorized transportation mode* is a sub-concept of *transportation mode*.
  + *consists of* indicates that a given concept is divided into several sub-concepts and that only the collection of all these concepts represents the upper concept. For example, a *user profile* consists of *routines*, *transportation preferences*, *social activities*, *social background*, and *medical history*.
  + *has* indicates that a given concept has certain properties. For example, the concept *person* has the properties *profile*, *goal*, and *state*. Here we model properties as concepts with relations to other concepts. A better explanation for the reasoning behind this can be seen in the discussion section.
* relations describing the interaction of the user (person) with other concepts. As the user plays the central role in an assistance system, these relations provide the information about his interaction with the environment.
  + *uses* indicates that a given concept (i.e., the user) makes use of another concept. For example, a *person* uses *transportation modes*.
  + *executes* indicates that a given concept (i.e., the user) can execute another concept. More precisely, in our ontology only the *person* can execute *actions* and *interact* with the environment.
  + *is applied on* indicates that one concept can be applied to another. This relation is used to indicate the types of elements in the environment the user can interact with. More precisely, the *interaction* concept can be applied on different types of *objects* in the environment.
* relations describing locational dependencies. These relations provide information about the types of locations a certain concept can be located at. They are important as situation-aware assistance heavily relies on the locational information to reason about the user situation.
  + *is at* indicates that a given concept is located at another concept that describes a type of location. For example, a *person* is at *location* where location can be a building, a street, etc.
  + *is executed at* indicates that a given concept is executed at a given other concept that describes a type of location. In difference to *is at* which is related to the *person* concept, *is executed at* is related to the interaction with the environment. For example, an *action* is executed at a given *location*.
* relations describing the causal dependencies between concepts. To derive the user intentions and the causes behind certain behavior, the system relies on causal dependencies between concepts.
  + *affects* indicates that a given concept is influenced by another concept (i.e., change in the intrinsic or extrinsic factors or the interaction with the behavior can change a concept). For example, the *physiological state* is affected by the *medical history* of the person.
  + *causes* indicates that the presence of a given concept causes the presence of another concept. For example, the *normal state* causes *normal action*.
  + *is achieved through* indicates that a given concept is the effect of another concept. More precisely, the *goal* is achieved through the *interaction with the environment*.

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**Supplementary Table 1.** Definitions of the concepts in the situation model for outdoor mobility of people with dementia.

|  |  |
| --- | --- |
| **Concept** | **Definition** |
| action | Normal behavior the person can execute in the environment. |
| animal | Animals with which the person is interacting. |
| animate | Living elements of the environment with which the person is interacting. |
| area | Extrinsic factor describing the type of geographical region where the person is located. |
| building | A location that is a structure with a roof and walls. |
| bus | Public mode of transportation involving a large motor vehicle carrying passengers by road. |
| buy an object | Haptic interaction involving exchanging money for an object in the environment. |
| car | Private mode of transportation involving a road vehicle, typically with four wheels, powered by an internal combustion engine and able to carry a small number of people. |
| close object | Haptic interaction involving changing the state of a container object from open to closed. |
| communication | Interaction which involves using speech or body language in order to communicate with another person. |
| communication action | Compensatory behavior where the person suffering from disorientation communicates with other persons in order to obtain the missing information. |
| completion error | The person does not realize that he has completed the task. |
| cross street | Action expressed in changing position from one side of the street to the other. |
| crossing | A location where two streets cross. |
| cycling | Non-motorized mode of transportation that involves the person using non-motorized vehicle to change location. |
| decision making | Choose between alternative routes. |
| direct communication | Communication with a nearby person. |
| do shopping | A goal that involves reaching a location where shopping can be done. |
| do sport | A goal that involves reaching a location where sports can be done. |
| drive a vehicle | Action expressed in using a vehicle to change locations. |
| enter a building | Action expressed in changing position by moving from the outside to the inside of a building. |
| challenging behavior | Challenging behavior describes behavior that deviates from the behavior expected to be observed in order to reach the user goal |
| errors due to disorientation | Errors in behavior caused by the disease. |
| evade obstacle | Action expressed in changing direction in order to avoid obstacle. |
| extrinsic factors | Extrinsic factors are factors outside of the person that are part of the environment and that influence the person’s behavior. |
| garden | A location located in an urban area where plants are being grown. |
| goal | Intrinsic factor describing the condition which the person wants to achieve by interacting with the environment. |
| haptic interaction | Interaction involving the physical manipulation of elements in the environment. |
| human | Human beings with which the person is interacting. |
| inanimate | Non-living elements of the environment with which the person in interacting. |
| initiation error | The person does not start the task. |
| interaction / manipulation | Normal behavior expressed in interacting with the environment. |
| interaction with the environment | The interaction with the environment describes the way in which the person is able to change the state of the environment. |
| intrinsic factors | Intrinsic factors are factors inside the person that influence his behavior. |
| irrational behavior | Challenging behavior caused by disorientation that does not attempt to obtain the missing information in order to reach the goal. |
| judgment and safety error | The person does not realize dangerous behavior |
| local conditions | Properties of the extrinsic factor that can change without the interaction of the user with the environment. |
| location | An extrinsic factor describing a specific landmark in an area. |
| long-term intrinsic factors (profile) | Intrinsic factors that describe long term conditions of the person as well as typical behavioral  patterns and abilities. |
| make eye contact with a person | Direct communication involving body language in order to communicate. |
| manipulate an object | Haptic interaction involving changing the state of an object through manipulation usually with the  hands. |
| medical history | Long term intrinsic factor describing any medical conditions associated with the person. |
| meteorological state | Local condition describing the weather condition of a given area. |
| mode of transportation | Extrinsic factor describing the means by which the person is changing locations. |
| motion | Intrinsic factor describing the change of the body trajectory. |
| motorcycle | Private mode of transportation involving a two-wheeled vehicle that is powered by a motor and has  no pedals. |
| motorized mode of transportation | Mode of transportation that involves the use of motorized vehicles. |
| non-motorized mode of transportation | Mode of transportation that does not make use of motors. |
| objects | Elements in the environment with which the person is interacting. |
| off-road | A location without a street where person can walk outside the city. |
| open object | Haptic interaction involving changing the state of a container object from closed to opened. |
| organization error | The person is unable to organize the tools necessary for executing the task. |
| perception | Perception during self-motion is characterized by a pattern of visual motion called optic flow. Information about heading direction and the three-dimensional structure of the visual environment can be inferred from that pattern. |
| person | The targeted user of the developed assistance system. |
| physiological state | The physiological state describes possible levels of physiological functioning during a task or condition. |
| planning | Construct a route between different locations, e.g., using cognitive maps. |
| private transportation | Motorized mode of transportation that involves using a private vehicle. |
| public location state | Local condition describing the state of a certain location such as office hours, renovations, etc., that might influence the behavior of the person. |
| public transportation | Motorized mode of transportation that involves using shared by the community vehicles. |
| put an object | Haptic interaction involving changing the object position from the hand of the person to a location in the environment. |
| rational (compensatory) behavior | Behavior observed when the person suffers from disorientation and attempts to compensate for it in a rational manner. |
| read a sign | Visual interaction involving making a visual contact with a sign in order to orient. |
| realization error | The person is unable to execute all steps necessary for the task completion. |
| remote communication | Communication with a person who is in a different location which does not allow direct communication. |
| rotational motion | Motion describing rotation of the person’s body. |
| routines | Long term intrinsic factor describing typical behavior patterns during the daily activities. |
| rural | Area in the countryside. |
| search for landmarks | Visual interaction involving observing the environment in order to orient. |
| sequence error | The person does not perform all task’s steps or does them in a different order. |
| sidewalk | A location that is a paved path for pedestrians at the side of a street. |
| social activities | Long term intrinsic factor describing preferred social activities. |
| social background | Long term intrinsic factor describing the social background of the person. |
| spatial action | Compensatory behavior where the person suffering from disorientation attempts to orient himself based on the surrounding environment. |
| spatial representation | Spatial representation describes the spatial reference frames used to mentally represent relative locations of objects to reference objects. |
| speak to a person | Direct communication involving speech in order to communicate. |
| state | An intrinsic factor describing a certain condition of the person. |
| street | A location that is a public road in a city or town. |
| take a walk | A goal that involves executing the action walk to a certain location and back. |
| take an object | Haptic interaction involving changing the object position from location in the environment to the hand of the person. |
| take public transportation | Action expressed in using public transportation to change locations. |
| technical affinity | Long term intrinsic factor describing the ability of the person to use technology. |
| topological action | Compensatory behavior where the person suffering from disorientation attempts to orient based on landmarks. |
| touch a person / object | Haptic interaction involving interacting with a person or object without changing their state. |
| train | Public mode of transportation involving a series of railroad cars moved as a unit by a locomotive or by integral motors. |
| tram | Public mode of transportation involving a rail vehicle which runs on tracks along public urban streets. |
| translation motion | Motion describing translation of the person’s body. |
| transportation preferences | Long term intrinsic factor describing the mode of transportation preferred by the person. |
| transportation state | Local condition describing the state of the modes of transportation that might influence the behavior of the person. |
| type 1 users | People that have technical understanding and interest in technology based on their professional experience. |
| type 2 users | People that have technical understanding and interest in technology based on their personal interests and hobbies. |
| type 3 users | People that have none or small interest in modern technology. |
| urban | Area in the cities. |
| use device to communicate | Remote communication involving the use of device in order to communicate with a person. |
| visit friends / family | A goal that involves reaching a location where family or friends are located. |
| visit the doctor | A goal that involves reaching a building where a doctor is located. |
| visit the garden | A goal that involves reaching a location where a garden is located. |
| visual interaction | Interaction involving eye contact but no physical interaction with the environment. |
| wait | Action where the person is staying at his position, but which is not caused by disorientation. |
| walk | Action expressed in changing positions in the environment. |
| walking | Non-motorized mode of transportation that involves the person changing locations by himself (through the action walk). |
| wandering | Irrational behavior expressed through aimless walking. |

1. For example, buying a bus ticket has a different meaning and implications than buying a cake. [↑](#footnote-ref-1)
2. The repositories contained information such as the types of dementia, or specific concepts related to the disease. They, however, did not contain any relevant information on factors influencing outdoor mobility in dementia. [↑](#footnote-ref-2)
3. Here, by *high-level activity* we mean complex activities such as taking the bus. This activity cannot be directly observed with a GPS sensor; however, it can be inferred based on the context information encoded in the situation model. [↑](#footnote-ref-3)
4. We have to note that generally speaking wandering could also describe an action in which the person is exploring and learning about the environment. It can also describe an action where the person is lost and is searching for directions. In our case, however, we use the term to describe a special type of wandering in people with dementia, expressed through aimless movement where the functionality of exploring or searching is lost. This behavior is often described as pacing [32]. [↑](#footnote-ref-4)