Ambient Assistance Using Mobile Agents

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***Abstract*—In this paper, a method is presented to assure ambient assistance in an urban environment, using a mobile agent. The goal is to anticipate the assistance if needed. Therefore, the robot has to understand the human behaviour and a person's needs. We will determine how to focus on a moving subject and using interaction for confirmation, in order to provide an assistance if needed. Therefore, the trajectory type concept is used to define the first step of analyses, which is called the approach step. Combining this step with the field information provided by the mobile agent will insure a certain type of assistance. In terms of observation, two different views are employed to detect assistance requirements, *i.e.,* the Fix Intelligent Device and the Ambient Intelligent Devices, both communicating by Wi-Fi. The Fix Intelligent Device is a fix camera standing on a very top view allowing the detection of possible motions and classification of trajectories, using neural network. In our research, a Touch Ambient Intelligent Device is utilized, a mobile robot with three degrees of freedom, including a 3D camera (*Kinect*^{TM}) and a touch screen to interact with the subject. In this paper, the behavior of the mobile agent, receiving detected trajectories emitted by the Fix Intelligent Device, is presented and it is shown that the human intervention is only needed in critical cases.**

Keywords-Human Activity Recognition; Ambient Assistance; Human Tracking; Robot Agent.

I. INTRODUCTION

The actual increased longevity in Europe and other developed countries [1] results in a fast growing population of senior citizens. Based on estimations [2], one-fifth of the elderly citizens will be 80 years and older by the middle of the century. Many elderly need nursing support to perform their normal daily activities, mostly due to the lack of strength or balance. Assistance robots can play an important role to reduce the workload of nurseries and increase the independence of elderly to perform their daily activities with little help from the people around them. At the same time, assistance robots developed for frail and disabled adults can be used for people with minor disabilities, as well.

That is one of the reasons that assistance robots have become one of the most rapidly developing fields in robotics. Among the assistance devices, there are some providing cognitive assistance and some increasing the mobility of the user.

A simple type of ambient assistance fully relying on human already exists. However, the disadvantages of this system are high costs, discontinuity and interpretation mistakes, such as animal detection, shadow, light, *etc*. A more complex type is using an automatic system (Vision, Sensors, *etc.*), employing the same disadvantages of interpretation mistakes eventually causing dangerous situations. In this work, the person's needs are interpreted, in order to provide assistance. The assistance robots described by Annicchiarico *et al.* [3] and Nagai *et al.* [4] are examples that can be used in displacement and transfer between two seated positions, respectively. Both examples are of relatively simple structure providing only a single type of assistance. While Chugo *et al.* reported a robot providing assistance for standing, walking and seating [5], Méderic *et al.* described ambient assistance for walking and the sit-to-stand transfer [6]. Assistance devices offering multi-support are normally large and of relatively complicated structure. Multi-robot assistance architecture has been proposed for frail and disabled adults in our laboratory [7] [8].

Our proposed system is designed for public places like waiting halls of train stations or airports or private places like apartments or offices.

The most challenging task is to understand the human behaviour, in order to understand a person's needs. In our research work, this detection is done by fusion of two different views to provide better results by having a continuous and safe automatic system. A robotic agent is used to confirm unclear information, *e.g.,* the doubt if the subject is a human, or only a shadow artefact movement. Therefore, our system proposes a solution to use humans only in critical cases.

In this paper, details of our system architecture are given first by explaining the role of the Touch Ambient Intelligent Device (TAID), followed by trajectory detections done by the Fix Intelligent Device (FID). The results of the combination of these two views (TAID and FID) are described subsequently. The experimental part with the results completes this paper, followed by the conclusion of our research.

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II. AMBIENT ASSISTANCE USING MOBILE AGENT

The architecture shown in Figure 1 allows to visualize simultaneously several movements of subjects, as well as to analyse their trajectories.

The trajectory detection is done by image capture at first. The assisting robot TAID has been developed for this project to act on the field (hospital, station, airport, *etc.*), when needed, or to confirm information.

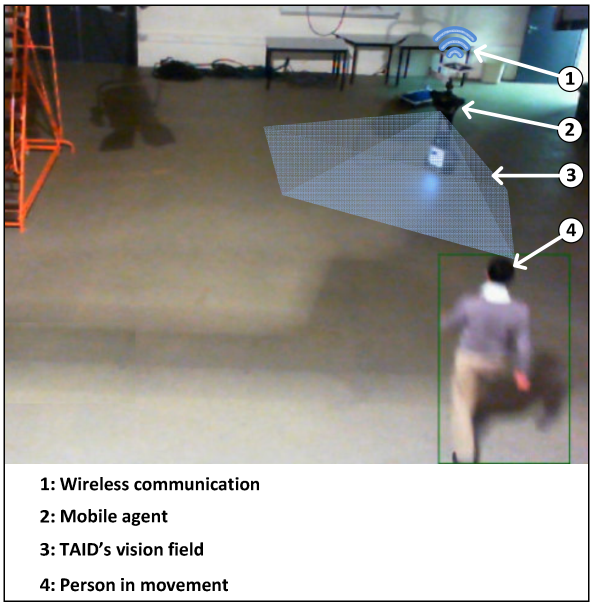

Figure 1. General view of the concept.

TAID is a robot with three degrees of freedom, allowing movement on X and Y axis, as well as rotation on Z axis (Figure 2). TAID is capable of lateral crablike movements, playing with direction and velocity of the wheel rotation.

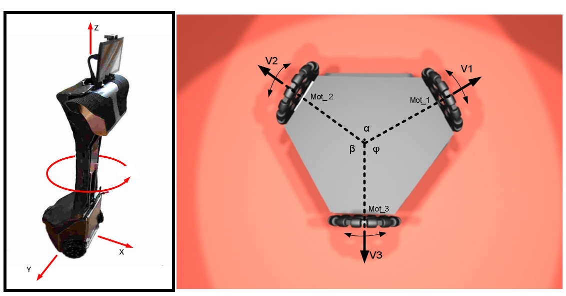

Figure 2. Degrees of freedom of TAID (on the left); Rotation axes of TAID's actions (on the right).

A robotic 3D sensor *Kinect*^{TM} of *Microsoft*^{TM} [9] has been embedded for simplification, allowing the detection and consequently the avoidance of obstacles, on top of the detection of subjects to determine their pose and to differentiate between human and animals.

A. *Robotic Assistance Description*

The communication between TAID and the subject is done by visual (*Vi*), tactile (*Ta*), vocal (*Vo*) or text interaction (*Te*).

Examples of interaction:

1. Subject: Making a hand signal → *Vi*.
2. TAID: Approaching and asking "DO YOU NEED HELP? RAISE YOUR RIGHT HAND FOR *YES* AND YOUR LEFT HAND FOR *NO*!" → *Te* and *Vo*.
3. Subject: Answering by giving the corresponding hand signal → *Vi* or by pressing the button *YES* → *Ta*.
4. TAID: Asking "WHAT INFORMATION DO YOU NEED?" → *Te* and *Vo*.

On the part of the robot, the question is always asked vocally, as well as by text using the robots graphic interface. The subject's response is then analysed by reading its gesture: Right hand raised for *YES* and left hand raised for *NO*. In order to avoid any incomprehension, vocal recognition was evaded, as the system is generally used in a noisy environment.

A quadrilateral transformation needs to be done primarily before a follow-up of any movement may start. The location of the camera has to permit the visualization of the platform to analyse.

B. *Movement Detection*

There are several approaches in a flux video for movement detection, based either on comparison of the current image video with one of the previous images (1), most commonly used, or with the background (2).

If a colour image is considered as example, a copy of the current image is done in grey scale, as well as of the previous image video. First of all, the region is determined by subtraction of the two different images. An image of white pixels is obtained at the place where the image $I(t_x)$ differs from the image $I(t_{x-1})$. If the surface is bigger than the defined lower limit, a movement alert is obtained. The inconvenient of this approach lies in the velocity of the object: If the object moves at a slow rate, the comparison of the current image with the previous image may provide insufficient results for object detection.

The comparison of the image $I(t_0)$ with the initial image $I(t_{in})$ allows the contour detection of a subject in movement, independently of the movement velocity. The inconvenient of this approach lies in the disappearance of the object: If an object is present during the first image capture of the background, but absent in the second image capture, the object is still detected at this place.

In our research work, a combination of these two approaches has been chosen, *i.e.,* the comparison with the

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image $I(t_{x-100})$. The advantage of this approach lies in the movement detection, even when the subject is moving at a slow rate and even when the reference image is still being up-dated. Thus, the problem of disappearing objects from the background is solved, as well as their permanent detection.

C. *Robot Interaction*

In the following section, the different interactions of the robot are presented.

1. Hand Signal

The agent may capture a hand signal and hence, may directly orient itself towards the subject for interaction. The interaction is done by vocal and written questioning/answering.

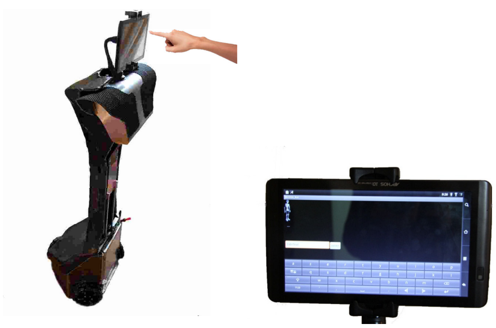

Figure 3. TAID's tactile interaction tool.

The mobile agent is using a tactile interaction tool, as shown in Figure 3, simplifying the interaction even in crowded and noisy environments.

2. Body Pose

The assisting agent TAID may detect a sitting or an on the ground lying subject, employing the 3D camera *Kinect^{TM}*.

The following two situations may occur, causing different reactions on the part of TAID :

- The agent detects the subject's falling down (subject standing and subsequently lying). In this case, the robot TAID will send an emergency alert.
- The agent detects a lying subject without knowing if the subject fell down or lied down on purpose. In this case, the robot TAID will interact with the subject first, asking him to confirm the need of assistance. For safety reasons, the robot will send an emergency alert after a certain time if the subject is not responding.

III. TRAJECTORY PATTERN

Five types of trajectories have been selected: Zigzag trajectory (A), circular trajectory (B), direct trajectory (C), back-and-forth trajectory (D) and random trajectory.

A. *Zigzag Trajectory*

A zigzag trajectory (T_Z) defines a hesitating or lost subject that does not know where to go. Hence, the goal is to assist the subject to regain orientation.

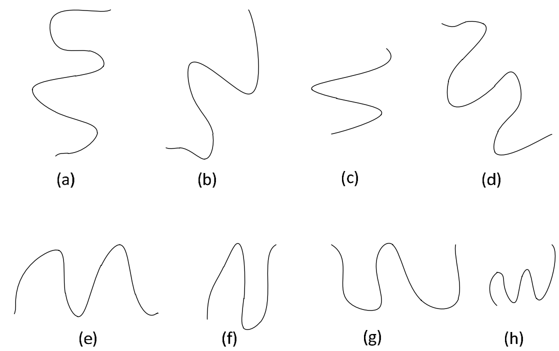

Figure 4. Examples of zigzag trajectories (T_Z).

Different T_z are possible, as it can be seen in Figure 4.

B. *Circular Trajectory*

A circular trajectory (T_c) can be a trajectory of a lost or waiting subject in movement, requiring assistance.

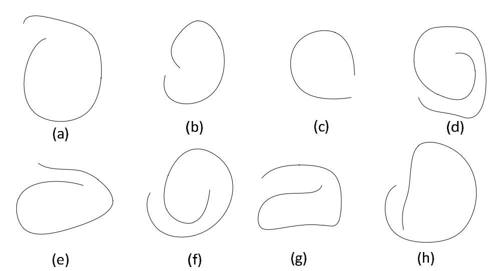

Figure 5. Examples of circular trajectories (T_c).

Figure 5 is representing some examples of such possible T_c.

C. *Direct Trajectory*

The direct trajectory (T_d) describes a decided subject, knowing where to go. The different possible paths are shown in Figure 6.

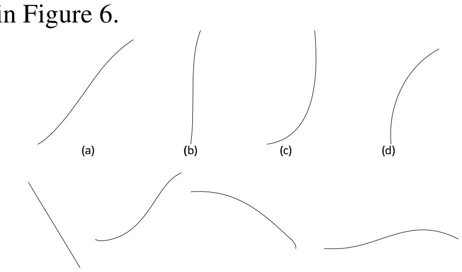

Figure 6. Examples of direct trajectories (T_d).

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D. Back-and-Forth Trajectory

A back-and-forth trajectory (T_b) helps to anticipate the agent's position, in order to have a fast intervention if a zigzag or a circle trajectory is detected (Figure 7).

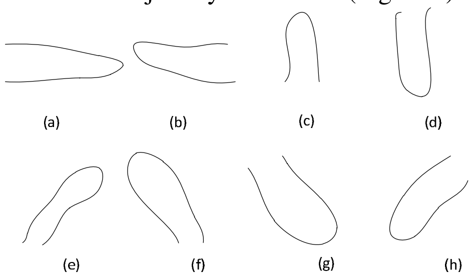

Figure 7. Examples of back-and-forth trajectories (T_b).

1) Trajectory detection

The detection of the trajectory type has been done by the use of a neural network [10] with 1000 inputs for each type of trajectory (Figure 8), allowing their classification.

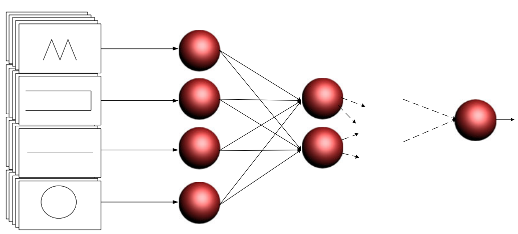

Figure 8. Illustration of the neural network model.

The fixed camera is connected to a computer *via* USB port, containing the algorithm of analysis and decision. The algorithm will transmit the command to the mobile robot TAID by Wi-Fi, using the User Datagram Protocol.

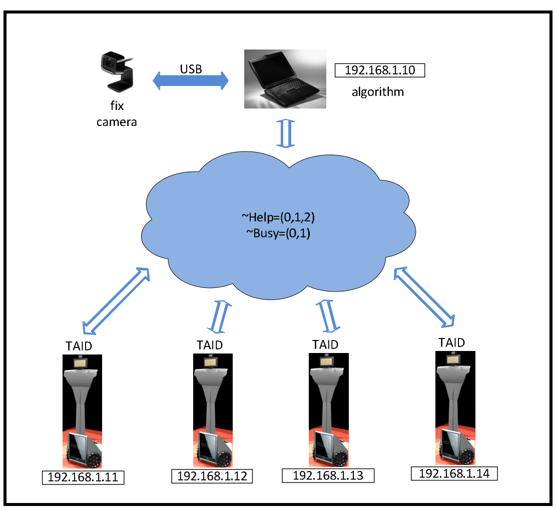

Figure 9. Illustration of the agent's communications.

Each mobile agent possesses its own IP address, as it is shown in Figure 9.

IV. SEMANTIC MODEL

During the agent movement, the FID is orienting the agent towards the circulating subject to have the possibility of information capture, emitted from the subject. The agents are able to detect following situations:

- A hand signal is coming from the subject [11]; this detection provokes TAID to approach the subject and to interact with the same.
- The subject is sitting or lying on the ground [11]; this detection provokes an emergency alert provided by TAID.

Figure 10 shows TAID's movement and its anticipation during analysis of the captured trajectory.

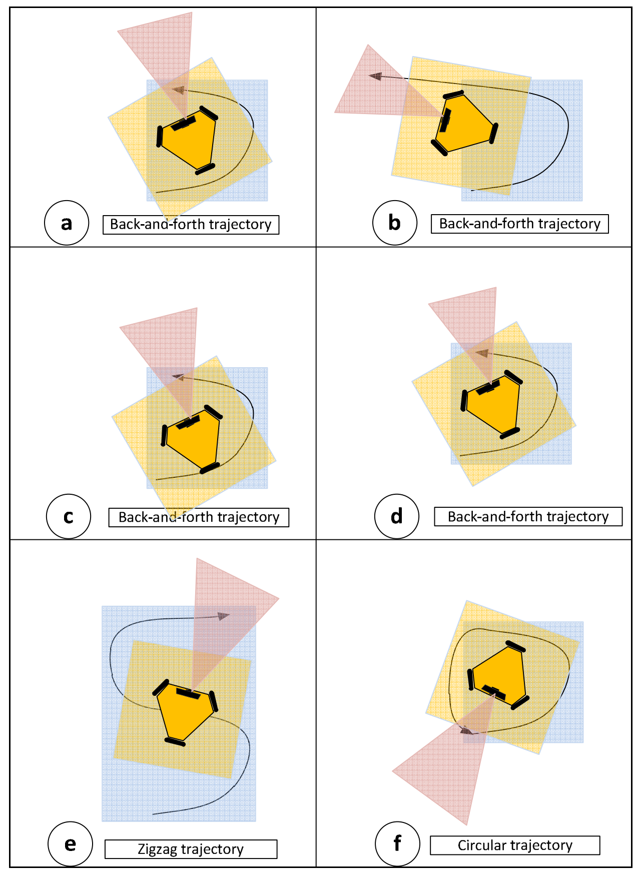

Figure 10. Examples of TAID's movement, based on the captured trajectory: (a-d) Back-and-forth trajectories; (e) Zigzag trajectory; (f) Circular trajectory.

V. EXPERIMENTAL SECTION

A volunteer was required to walk around in the test area, respecting certain trajectories and repeating these trajectories 9 times. Figure 11 illustrates the resulted trajectories.

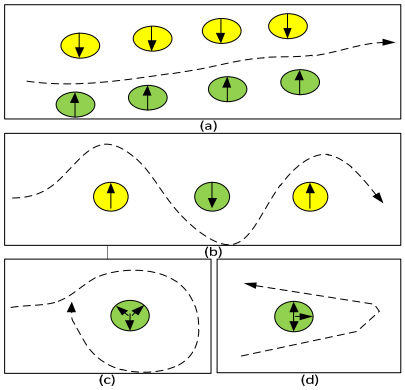

Figure 11. Illustration of the tested trajectories: (a) Direct trajectory ; (b) Zigzag trajectory; (c) Circular trajectory; (d) Back-and-forth trajectory.

The algorithm applied in our system is depicted in Figure 12.

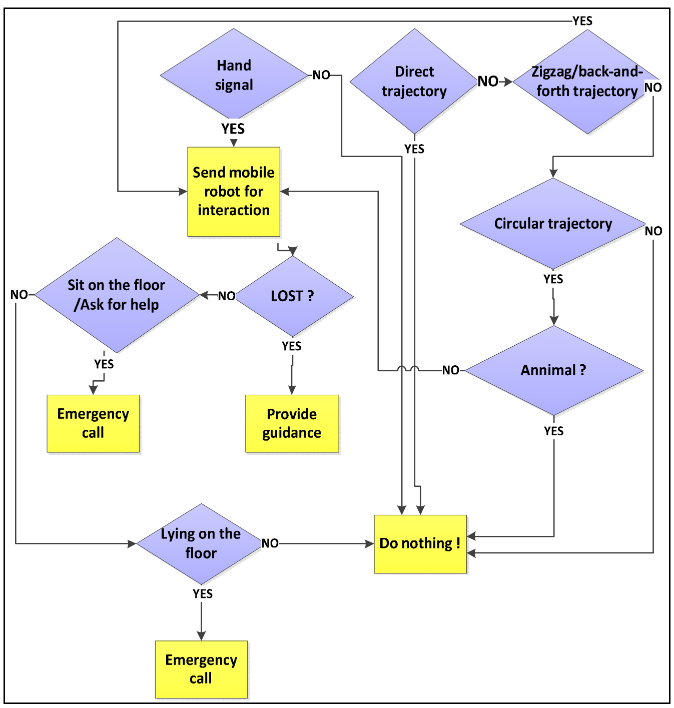

Figure 12. Illustration of the system's algorithm.

A. *Detection of a Direct Trajectory*

If the FID detects a direct trajectory T_d, TAID will orient itself towards the subject in movement without approaching the same.

The rotation angle α(TAID, moving subject) is calculated subtracting the β(TAID, X axis) angle and the γ(moving subject, X axis) angle.

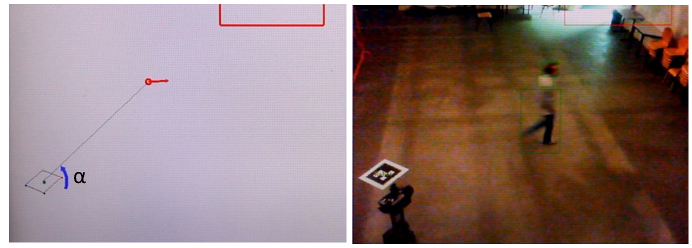

Figure 13. Illustration of the orientation of the robot TAID.

In Figure 13, the orientation of the mobile agent is illustrated. The red arrow represents the motion direction of the subject in movement, which allows knowing if the subject is directing itself towards an area of danger. The blue arrow represents the rotation that the robot has to execute, in order to observe the subject in movement.

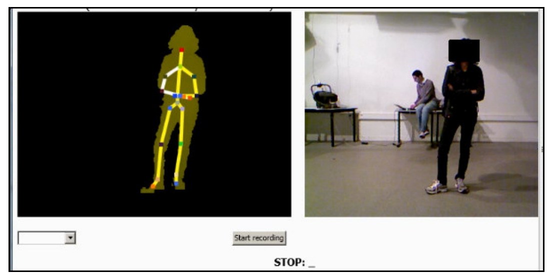

Figure 14. Illustration of TAID verifying the hand sign and the body pose.

TAID is always checking for hand signals asking for help, as it is shown in Figure 14.
However, the robot may detect a falling subject pointed by the FID, employing the 3D camera *Kinect*^{TM}.

B. *Detection of a Nondirect Trajectory*

If the fixed camera detects a zigzag trajectory T_z, the robot will receive the information of intervention with the detected individual. The mobile agent TAID will interfere and progress towards the subject, in order to verify its condition and to interact with the same. After having moved, TAID will collect the following information: size, corpulence and pose of the subject (standing, sitting on the ground or lying down).

In the case of a standing subject, the robot TAID will only ask if the subject needs help and if yes, what kind of help. The interaction is done on the level of the tactile screen of the robot. If a subject is sitting on the ground, TAID will transfer the information to the FID. The agent TAID will send an emergency alert, in order to get a human intervention, when a subject is lying in the ground.

V. RESULTS

In our experiments, each trajectory was tested 9 times, which allowed obtaining 91.67 % successful results. Examples of trajectory detection are given in Figure 15.

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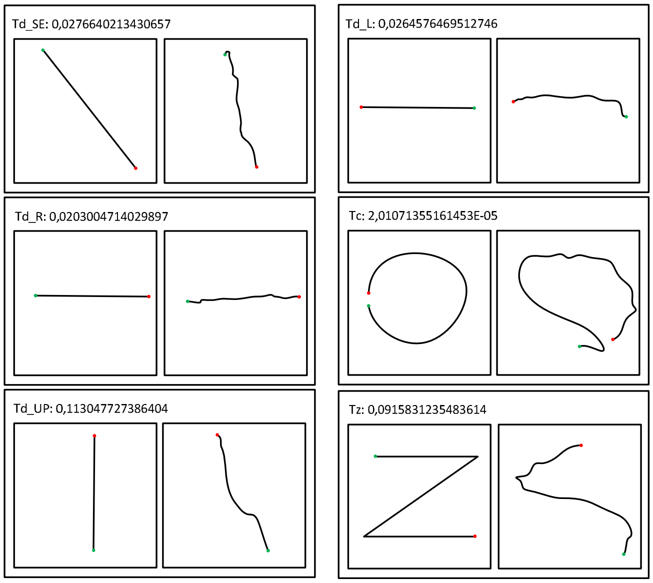

Figure 15. Examples of trajectory detection.

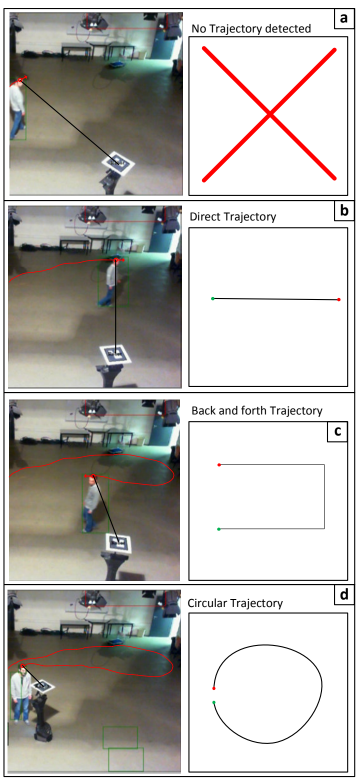

Figure 16. Illustration of trajectory detection and interaction of TAID with a person.

In Figure 16-a, the FID is not detecting any trajectories because of insufficient points.

In Figure 16-b, the FID is detecting a direct trajectory. Hence, the robot is waiting, in case the subject fells or makes a hand sign.

In Figure 16-c, the FID has detected a back-and-forth trajectory. Subsequently, the robot TAID approaches the subject in movement.

In Figure 16-d, the FID has detected a circular trajectory (same result if zigzag trajectory is detected). Consequently, the robot TAID is sent to interact with the subject, asking if help is needed.

If the object in movement is an animal, the intervention will be cancelled, as TAID is able to distinguish between humans and animals.

VI. Conclusion and Future Work

The results show that assistance on a subject by human intervention is only needed in the most critical cases. The analysis of trajectory behaviour helps to make a distinction between decided and hesitating subjects. This pre-analysis allows the mobile agent to approach the hesitating subject, in order to interact as fast as possible. Therefore, the definition of a trajectory can be changed, according to the environment. Having two different views helps the system to confirm unclear cases, such as detected animals or vehicles.

The future work will consist in testing our system with more than one subject, as well as with more agents in the field. This will allow the development of the communication between the agents and the determination of how interaction priorities can be managed between the present agents.

References

[1] R. Rosales, and S. Sclaroff. Trajectory Guided Tracking and Recognition of Actions. BU-CS-TR-99-002: Publisher Boston University Boston, MA, USA ©1999, 1999. http://dcommon.bu.edu/xmlui/bitstream/handle/2144/1779/1999-002-trajector-guided-tracking-and-action-recognition.pdf [retrieved: April, 2012].

[2] R. Bodor, B. Jackson, and N. Papanikolopoulos.Vision-Based Human Tracking and Activity, in Proc. of the 11th Mediterranean Conf. on Control and Automation, Vol. 1 (2003). http://mha.cs.umn.edu/Papers/Vision_Tracking_Recognition.pdf [retrieved: April, 2012].

[3] R. Annicchiarico, C. Barrué, T. Benedico, F. Campana, U. Cortés, and A. Martínez-Velasco, The i-walker: an intelligent pedestrian mobility aid, in ECAI 2008 - 18th European Conference on Artificial Intelligence, Patras, Greece, July 21-25, 2008, Proceedings, pp. 708–712, 2008. ISBN: 978-1-58603-891-5. http://www.diagnostic-walker.es/pubs/iWalkerPatras.pdf [retrieved: April, 2012].

[4] K. Nagai, I. Nakanishi, and H. Hanafusa, Assistance of self-transfer of patients using a power-assisting device, in IEEE Int. Conference on Robotics and Automation, p. 4008 U4015, 2003. ISBN: 0-7803-7736-2.

[5] D. Chugo, T. Asawa, T. Kitamura, S. Jia, and K. Takase, A motion control of a robotic walker for continuous assistance during standing, walking and seating operation, in IROS, pp. 4487–4492, 2009. ISBN: 978-1-4244-3803-7. http://cdn.intechopen.com/pdfs/8624/InTech-A_motion_control_of_a_robotic_walker_for_continuous_ass

istance_during_standing_walking_and_seating_operation.pdf [retrieved: April, 2012].

[6] P. Méderic, V. Pasqui, F. Plumet, P. Bidaud, and J. Guinot, Design of a walking-aid and sit-to-stand transfer assisting device for elderly people, in 7th Int. Conference on Climbing on Walking Robots (CLAWARŠ04), 2004. http://www.isir.upmc.fr/files/2004ACTI97.pdf [retrieved: April, 2012].

[7] C. Riman, E. Monacelli, I. Mougharbel, A. El Aij, Y. Alayli, "A Multi-Interface Platform System for Assistance and Evaluation of Disabled People", First Number Special Issue on Assistive Robotics, Applied Bionics and Biomechanics Journal, vol. 8, pp. 55-66, 2010.

[8] E. Monacelli, F. Dupin, C. Dumas, P. Wagstaff, "A review of the current situation and some future developments to aid disabled and senior drivers in France", Elsevier Masson BioMedical Engineering and Research, IRBM, 30, pp 234–239, 2009.

[9] Microsoft, *Xbox 360 Kinect Sensor Manual*, October 2010. http://www.xbox.com [retrieved: April, 2012].

[10] C. Schüldt, I. Laptev, and B. Caputo, Recognizing Human Actions: A Local SVM Approach, 17th International Conference on Pattern Recognition (ICPR'04) - Volume 3, 2004**.** ftp://ftp.nada.kth.se/CVAP/users/laptev/icpr04actions.pdf [retrieved: April, 2012].

[11] M. Khalili, E. Monacelli, and Y. Hirata, Identification of pedestrian characteristics for assistive systems, in *IEEE/SICE International Symposium on System Integration (SII 2011)*, 2011.