Demo : Fall Detection Using 3D Head Trajectory Extracted From a Single Camera Video Sequence

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***Abstract*— In Western societies, the population grows old, and we must think about solutions to help them to stay at home in a secure environment. By providing a specific analysis of people behavior, computer vision offers a good solution for healthcare systems, and particularly for fall detection. This demo will show the results of a new method to detect falls using a monocular camera. The main characteristic of this method is the use of head 3D trajectories for fall detection.**

Keywords : fall detection, video surveillance, monocular camera, 3D trajectory, tracking, particle filter, smart home.

I. Introduction

Falls are one of the greatest danger for older people living alone. The usual solution to detect falls and call for help is the use of wearable fall detectors like accelerometer or help buttons. But older people often forget to wear them or can be unconscious after the fall. Computer vision systems offer a new automatic solution to overcome these limitations.

Some researchers have already developed fall detection system using image sensors. One example is the work of Lee and Mihailidis [3] who detect falls with the shape of the person's silhouette using a camera mounted in the ceiling. We present here a new method using 3D data of the head trajectory which allows to track the movement of the fall and to really distinguish a fall from any normal situations.

II. Method

A. Description

Our method [4] is based on three steps :

- Head tracking : because the head of the person is usually visible in the image and has a large movement during a fall.
- 3D tracking : the head is tracked with a particle filter to extract a 3D trajectory.
- Fall detection : a fall is detected using 3D velocities which are computed from the 3D trajectory of the head.

B. Head Localization

We propose to model the head by an ellipsoid in 3D which is projected as an ellipse in the 2D image plane. To localize the head of the person, we use the algorithm of Dementhon [1] which takes three input arguments : the 3D points of the head model, the 2D corresponding points projected in the image plane and the intrinsic parameters of the camera obtained from a calibration of the camera. The output of the algorithm is a 3D pose of the head in the camera coordinate system which we can convert in the world coordinate system attached to the XY ground plane. To recover the 3D trajectory, we choose to track the head using a particle filter.

C. 3D Tracking

The advantage of particle filters [2] is that they allow abrupt variations on the trajectory and can deal with small occlusions. Usual methods to track the head using particle filters work well but with small movements. In our case, the movement can be very large because of the fall, so we need to adapt existing methods to overcome this problem. We propose to adjust the particles in three steps. The first particle filter looks around the last position of the ellipse. If it doesn't find the head, a second particle filter is used to search forward an approximated position of the head in the new image, and the third particle filter refines the position. The particle filters are based on the gradient magnitude around the ellipse perimeter and the likelihood of foreground color inside it. Some results are shown in Fig. 1.

D. Fall Detection

A biomedical study with wearable markers [5] proposes to use the vertical velocity Vv and the horizontal velocity Vh in the world coordinate system to distinguish falls from normal activities. Our 3D trajectory extracted from the video is used to compute these characteristics in the aim of being able to detect a fall using a camera but without markers. By thresholding the vertical velocity Vv and the horizontal velocity Vh, we are able to detect a fall. An example of velocities obtained from a 3D trajectory is shown in Fig. 2.

III. Demonstration

Our fall detection system is composed of a single camera placed in a top corner of the room. We use a low-cost system composed of a USB webcam with a wide angle of

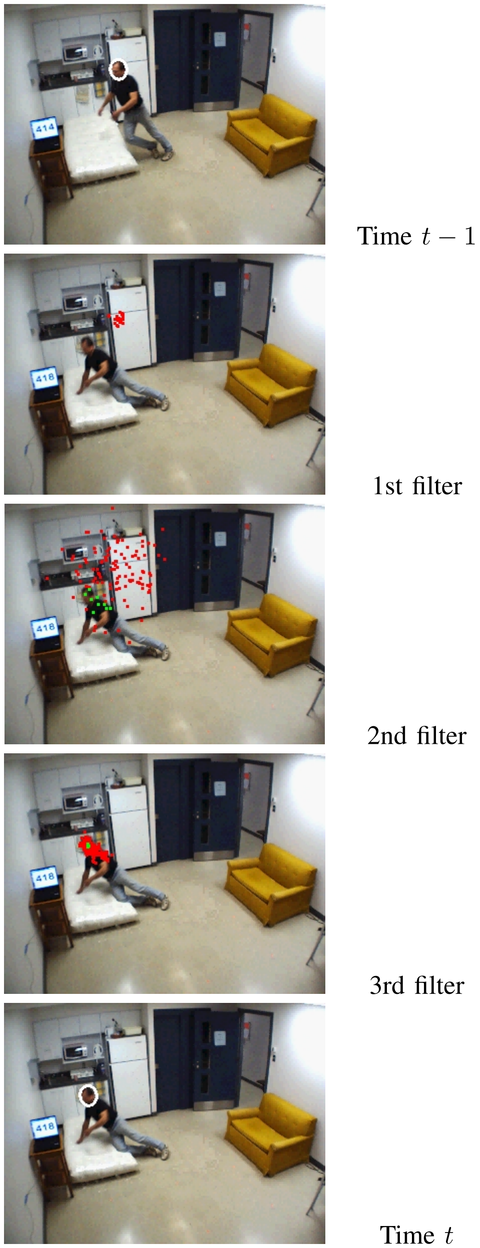

Fig. 1. The use of the three particle filters for a fall. The green particles are the best particles of the filter, and the red all the others.

more than 70 degrees to see all the room (Creative Live! Ultra). This system gives low-quality images (compression problems, noise), and image distortion due to the wide angle.

With this system, we acquired a set of videos in various situations : falls and normal situations like sitting down or squatting. The characteristics of the image sequences are a size of 640x480 pixels and a frame rate of 30 Hz. The demonstration will show the results of 3D tracking of the head on videos, and presents some results of fall detection using velocity characteristics.

Currently, our 3D tracking system works on matlab, but a C++ version will be done soon using OpenCV library (Intel Open Source Computer Vision Library).

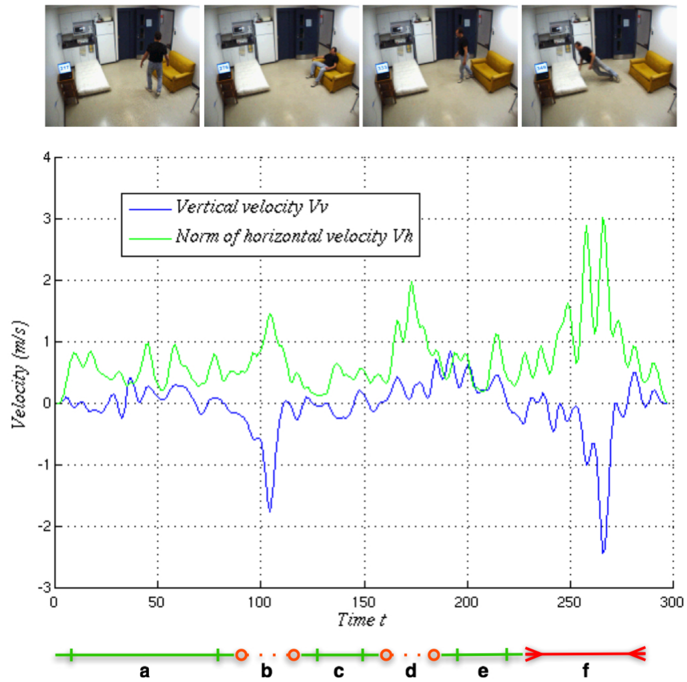

Fig. 2. Illustration of vertical velocity Vv and horizontal velocity Vh. These velocities were obtained without markers from the 3D trajectory of a person who brutally sits down and falls. The different actions are : the person (a) stands up, (b) sits down, (c) is seated, (d) stands up again, (e) remains stand up and (f) falls

IV. Conclusion and Future Work

3D velocities extracted from a single camera video sequence offer a new method to detect falls. The tracking of the head of the person gives us a 3D trajectory, useful to distinguish falls from any normal situations. However, some points need to be improved. Currently, the ellipse representing the head in the first image is manually initialized, we will therefore develop an automatic method to detect the head when the person arrives in the room. We also plan to further improve the crucial part of the system, head tracking, to enhance our fall recognition system.

References

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