GAIT ANALYSIS USING MS KINECT PLACED ON THE MOBILE ROBOTIC PLATFORM

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Abstract

Computer vision is a fast developing field of science, that comprises gait monitoring, which is the main focus of our appication. on gait monitoring and analysis. The novelty of this work is combining MS Kinect v2 sensor for capturing the gait pattern and a robotic platform, thus having a mobile device.

Crucial part of this project is the hardware solution and autonomous function of the aforementioned recording platform. The designed platform is a six-wheeled robotic platform controlled by a micro controller, which uses the depth information from the Kinect sensor and the distance driven provided by encoders, that are attached to every motor.

The following research is devoted to the proposal of methods for a precise control of the platform and post processing of records for a features selection and a classification of physical activities and early diagnostics of gait disorders, primarily the Parkinsons disease.

1 Introduction

Robotic motion platforms in combination with computer vision systems are commonly used in medicine nowadays. For example, systems that enable observations and early diagnostics, even more with non-invasive methods, are important and interesting. One of these non-invasive computer vision systems is a motion sensing input device Microsoft Kinect.

A Kinect navigated robotic platform is used in [4] to follow elderly people. The authors Stone E. and Skubic M. proposed an application of the Kinect sensor for a in-home gait measurement to prevent people with Parkinsons disease from falling [8]. Kinect is also used for tracking speed skaters [1] to collect data for their trainers. The authors use a standard RC(remote controle) car as a carrier for their equipment, including MS Kinect sensor. All of the aforementioned authors use infra-red and/or depth data provided by Kinect for their tracking algorithms. Another way for tracking people is using stand-alone stereoscopic camera [6, 2] in combination with a Laser Range Finder (LRF) [7]. Authors use feature detection to extract individuals from captured images. After that, position of the selected region, colour and texture of their clothes are used for improving the recognition in subsequent images. LRF is also used as an obstacle avoiding system, LRF data and the camera system data fusion brings even more precise results.

Kinect was originally developed as a console for Xbox, so apart from depth and infra-red images it provides even skeletal data of tracked people, because algorithm for detecting people is already included. New Kinect v2 can track up to six people at once and provide position of 25 major joints from two people. This feature is often used during rehabilitations to record the progress of a healing process. Several papers [5, 9] discussing Kinect as a sensor of gait patterns was written at our department. In these papers Kinect provides skeletal data that are processed for specific features like co-movement of legs and arms. These features are unique for every person, just like a finger print, but some neural diseases have impact on the gait pattern, which are then changed in a specific way common for most patients.

Previously mentioned papers are very interesting and we were inspired by them while creating our system. One of our innovations lies in the fact that we use our mobile robotic platform in conjunction with Kinect v2 (Fig.1), which provides more precise depth and infrared data. Another difference lies in the approach of positioning the moving robot in front of the patient with usage of cameras viewing backwards, thus providing a more natural and unobstructed recording environment.

2 Motivation

The gait analysis involves a measurement, an extraction of the well-describing features and an interpretation of the results leading to a conclusion about the health of the subject. The process of measurement is highlighted in this paper. There are several techniques how to observe the gait pattern. There are two main categories of features that have to be observed during the gait tracking. Temporal and spatial measurement provides features such as walking speed or stride length. This process is usually carried out by a stopwatch and marks on the ground, walking on a pressure mat, laser sensors placed few centimetres above the ground or inertial sensors (gyroscopes and accelerometers). Measurement of Kinematics could be performed by following methods:

- Chronophotography is using strobe lighting at a known frequency and capturing the images.
- Cine film or video recordings from a single or multiple cameras to measure joint angles and velocities. This method allows analysis in three dimensions.
- Passive marker systems consist of reflective makers and multiple cameras (up to 12) sensitive to the reflection of used materials (usually red, infrared or near infrared).
- Active marker systems are based on a similar philosophy as the passive markers with the exception that the markers are triggered by the incoming signal.
- Inertial systems do not need any camera and the movement is captured by a set of sensors. Each sensor is a combination of a gyroscope and an accelerometer. The gait tracking is inferred according to a biomechanical model and a fusion of information from all sensors.

Figure 1: Photography of a mobile robotic platform with Kinect v2.

All these methods need some special equipment, wearable sensors limiting the movement or sensors dedicated to one purpose. Our method of capturing the gait pattern is using the MS Kinect sensor providing the skeletal tracking function. The skeletal tracking function enables to determine the position of the 25 main body joints derived from the depth frame (algorithm by J. Shotton and others). The disadvantage is the limitation of the Kinect sensor field of view, enabling reliable tracking of people only at distances between 0.5 m and 4.5 m. Therefore the combination of the cost-effective Kinect sensor and the mobile robotic platform is opening new possibilities to track the gait pattern.

In the previous studies [5, 9] the Kinect device was placed stationary on a table to track people in its field of view. MS Kinect that was used for data acquisition was installed approximately 60 cm above the floor. Each individual repeated a straight walk of approximately 4 m (five steps) back and forth 5 times. The experimental portion of this study was devoted to the analysis of the gait of the following two sets of individuals: 18 patients with Parkinsons disease and 18 healthy age-matched individuals. From the acquired records 5 features were extracted walking speed, stride length, center of mass deviation in the horizontal and vertical projection and limb synkinesis. The results were obtained by a combination of these characteristics by a neural network and the accuracy of decision of this system was up to 91.7 %.

3 Equipment of Platform

The platform was developed as a six wheeled remote controlled robotic platform. Each wheel is equipped with a motor with an encoder and a driver. The motors are high power and their maximal rated consumption is about 4 amps with 7 V supply each. Each motor has also a gearbox attached with a 75:1 gear ratio; together they provide enough torque to climb a 60° slope. The maximal speed is about 3.5 km/h and it is measured by quadruple encoders attached directly to the motor shafts. Each encoder provides 24 pulses on each channel per revolution, so there are approximately 3600 pulses per revolution of a wheel. Each motor has our custom full H-bridge driver, which is controlled via the SPI. The driver can supply the motor with up to 5 amps continuously without any additional heat sink [3].

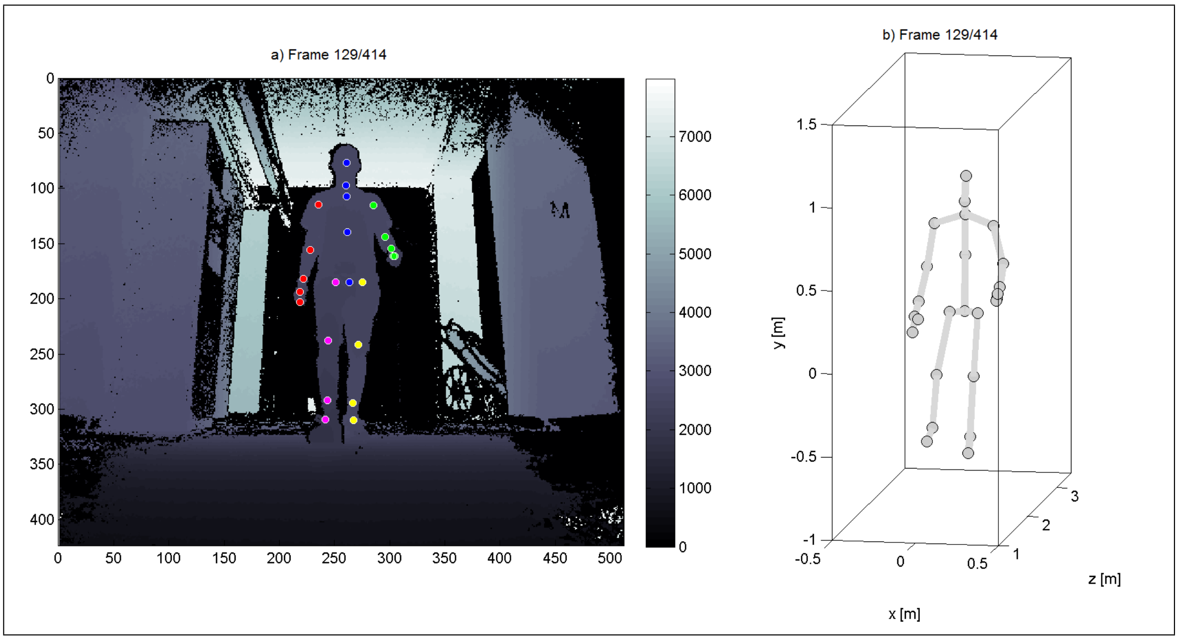

Figure 2: a) Depth map with highlighted body joints and b) 3-D skeleton model of one selected frame during recording.

4 Gait Reconstruction

The next step in the process of gait tracking is to reconstruct the gait pattern from the captured raw data. For the recording purpose a *C#* application was written to store the recorded skeleton data from Kinect and the information about the distance driven by the robot.

Data from Kinect contain a 3D position of the 25 joints returned by the skeletal tracking function and a time stamp of each frame (see Fig.2). In the application for data recording there is a procedure that (after the frame is returned from Kinect) sends a request to the ARM micro controller and the answer is the distance travelled by each of the six wheels. This distance driven by each wheel is necessary to compute the overall robot movement and figure out the exact direction the MS Kinect device is facing at this frame. For modelling the gait pattern the movement of the robot is subtracted in the processing.

The most common and the most required case is movement of the robot only in one axis. If there is an operational interference of the ARM processor, it is necessary to alter the absolute 3D position of the joints. For verification of the correct process of the gait reconstruction it is possible to observe a centre of the mass (COM) movement. If the processing is successful, the COM position is fixed, only with the regular deviation corresponding to the swings of the legs. On the other hand, there will be a discontinuous movement of the COM if the reconstruction is wrong. COM position is relative to the robot actual direction, Fig.3 is documenting this statement.

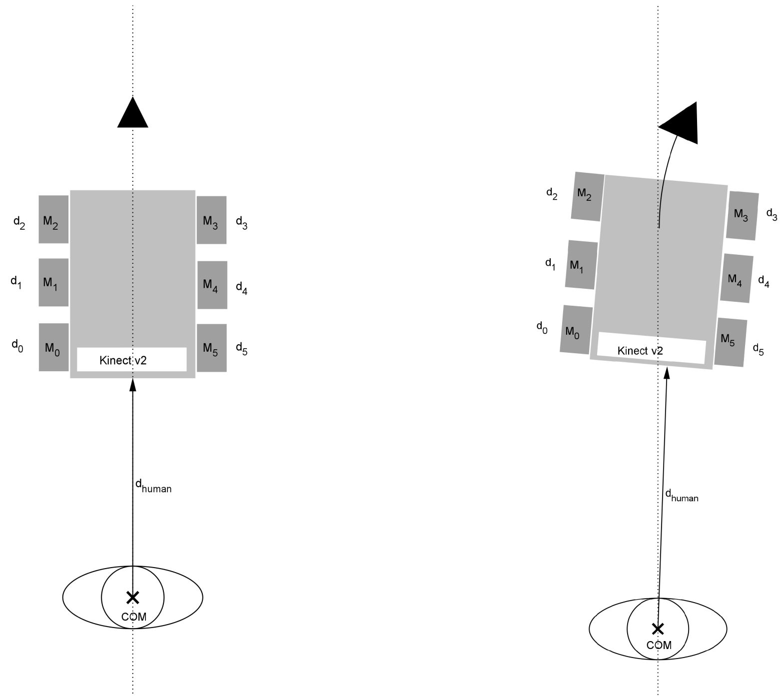

Figure 3: Robot movement scheme proving the high influence of the robot actual direction to the COM of a subject position

After the reconstruction of the gait pattern feature extraction follows. The temporal and spatial gait characteristics are the walking speed and the stride length. The features describing the kinematics of the gait pattern are computed on the static skeleton. The static skeleton refers to the situation, where the general movement distance travelled by all joints is subtracted. On the static skeleton it is possible to reveal the limb synkinesis, COM deviation and other details different from the periodic gait pattern.

5 Conclusion

Contemporary result of this project is the hardware solution of the robotic platform. This platform can perform autonomous measurements that are used for gait analysis. The platform can alter the behaviour in different scenarios to avoid possible problems during the measurements. The control of the platform is still in progress and there are some details waiting for more precise and specific solutions and to generalize the overall control.

The project is now in testing phase in the laboratory settings at our university. We are setting different situations and scenarios that will probably occur in the future in the neurology department of Faculty hospital in Hradec Králové. We are trying to automatize the control to achieve precise pathing of the platform. Another goal is to create a user-friendly program for recording, which will be handled by staff of the hospital.

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