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SYNTHESIS OF INERTIAL POSITIONING ALGORITHM

Ua Представлено метод визначення координат із використанням вбудованих у мобільний телефон інерціальних датчиків. Роботу методу показано на прикладі декількох експериментальних результатів.

Ru С помощью встроенных в мобильный телефон инерциальных датчиков предложен метод определения координат. Работа метода показана на примере нескольких экспериментальных результатов.

Introduction

The paper are contains the result of coordinate determination with the devices built-in inertial sensors. The positioning is performed in nonmoving start reference coordinate system. An inertial coordinate determination algorithm is

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created. The algorithm is sets the current biases of inertial sensors to zero while the IMU is nonmoving state. The components of current ground speed are set to zero as well, while the IMU is nonmoving state. The algorithm operates with real data from Gear VR. Scenario of moving is the following:

1. to diagonal on 1 meter and return,
2. to straight line on 1 meter,
3. to circle in vertical plane.

Algorithm description

The algorithm is performed by the initial alignment in movement starting (fig. 1) in the initial alignment block. The initial alignment is performed by accelerometer sensor data from accelerometer block. It determining the angular displacement from horizontal plane. The matrix of guide cosines can be found by this angular displacement in "initial alignment block" as well. In the "projecting block" the projecting of accelerometer vector to horizontal plane is performed and g-module from the accelerometer vertical project is calculated. In the "projecting block" the projecting of accelerometer vector to horizontal plane is performed and g-module from vertical component of accelerometer block is calculated.

The acceleration in "differentiated block" is determined and the moving state in "if moving block" is checked by the following condition:

$$|a_i - a_{i-1}| > \dot{a}_{Max},$$

where a_i is acceleration of i step, $\dot{a}_{Max}$ is a maximum difference of accelerations.

If the moving state is absent, the acceleration is written for the individual data array in "acceleration data array block" and velocity is set to zero in appropriate block. If the time in the state position is exceed the time $t_{stopMax}$, the median of past N data from acceleration data array is calculated. This median is zero bias of accelerometers.

The zero bias of accelerometer is increasing in time in static position. The "accelerometer writing block" is calculated. Therefore, this zero bias is subtracted from accelerometer output value in moment of moving start in "zero bias subtract block". This result is assumed as an apparent acceleration of moving. The apparent acceleration is double integrated in "double integrated block" to obtain the moving object position.

The output signal of angular rate block of the moving object is amenable to a similar procedure with single integrating of apparent angular rate.

Results of algorithm operation

In scenario of moving to straight line on 1 meter, the following devices are used: precision IMU STIM 300 (fig. 2) with 0,4 deg/hour bias instability and rough IMU (fig. 3) Bosh, it is embedded in VR Gear.

The angular position determination is presented in the left-upper cell in fig. 2 … fig. 6 (upper part of first column).

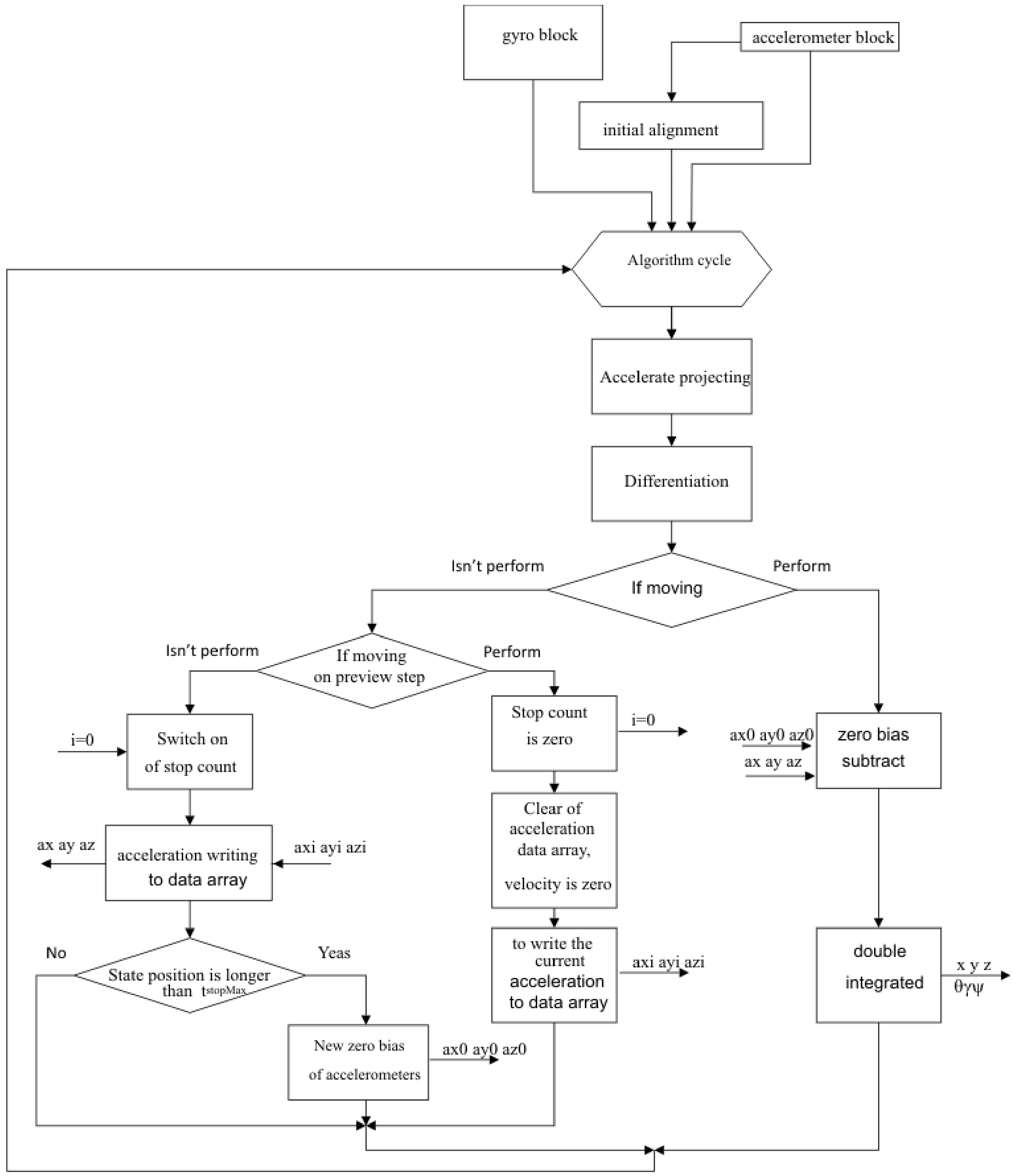


Fig. 1. The block diagram of the algorithm

The error of angular position determination is not more than 0,1 deg for precision IMU and is not more than 1 deg for rough IMU. The error of coordinate position determination (second columns on figures) is not more than 0,1 meters for precision IMU (fig. 2) and is not more than 0,25 meters for rough IMU (fig. 3).

It is admissible for purposes of virtual reality and it is responsible for technical requirement of this research work. The green line on the figure presented the devices ideal trajectory.

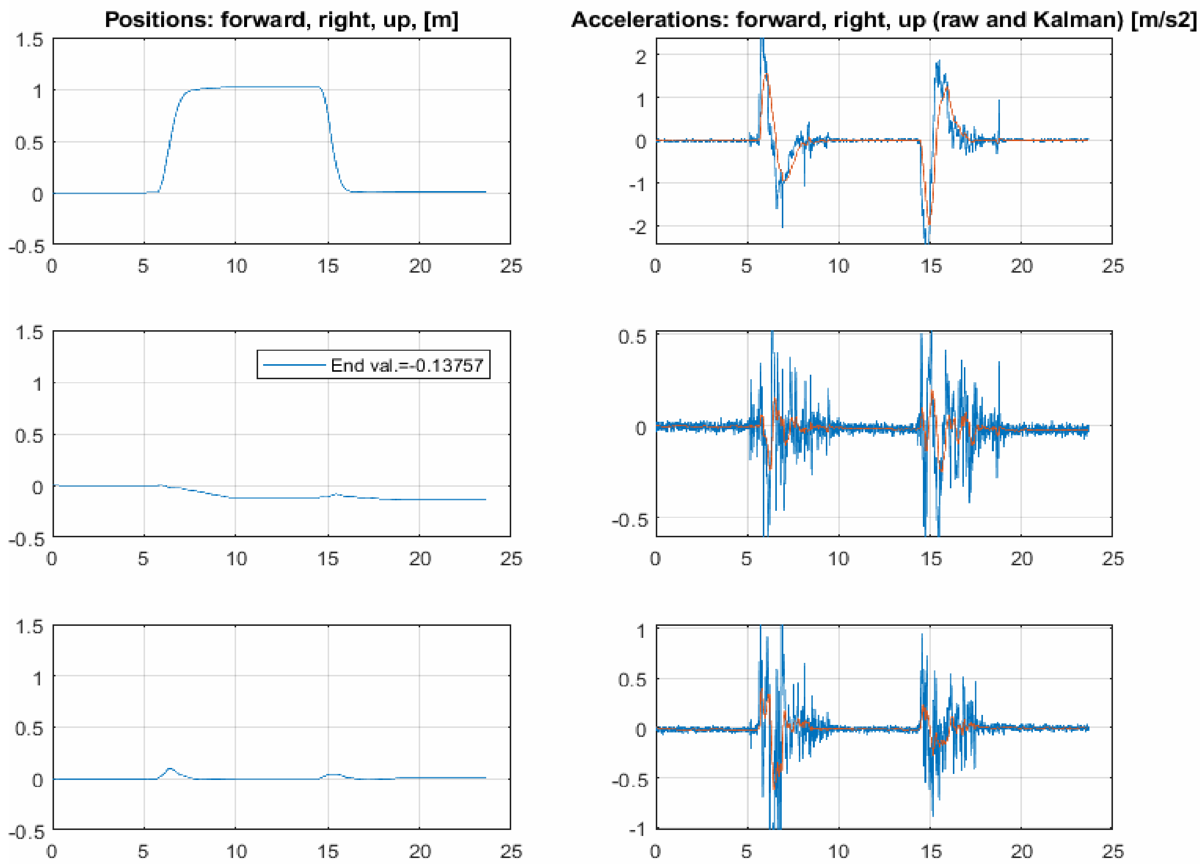


Fig. 2. Forward and back moving on 1 meter in horizontal plane (STIM 300 IMU)

The moments of counter switch on and moments of exceeding the criteria of nonmoving limit are presented in the medium and bottom cells of the first column in all figures. The nonmoving limit is $1{,}5\cdot10^{-3}$ m/s^2 for all moving scenario. The algorithm is switched on only for the longest time (more than $t_{stopMax}$) non-moving state and it is "cut off" of zero bias of each sensor. The biggest accelerations of devices are existed in the fist coordinate – OX in fig. 2, fig. 3, the third column.

In the other moving scenarios, significant changes in acceleration occur in two coordinates: in fig. 4 – forward and right, in fig. 5 and fig. 6 – right and up. In moving along two coordinates, the big error occurs along the third coordinates: in fig. 4 – along up coordinate with value up to 0,3 meters, in fig. 5 and fig. 6 – along forward coordinate with value up to 2,5 meters. This coordinate does not participate in the moving.

Whereas, along the coordinate of the real moving, the error does not exceed 0,05 and 0,5 meters respectively.

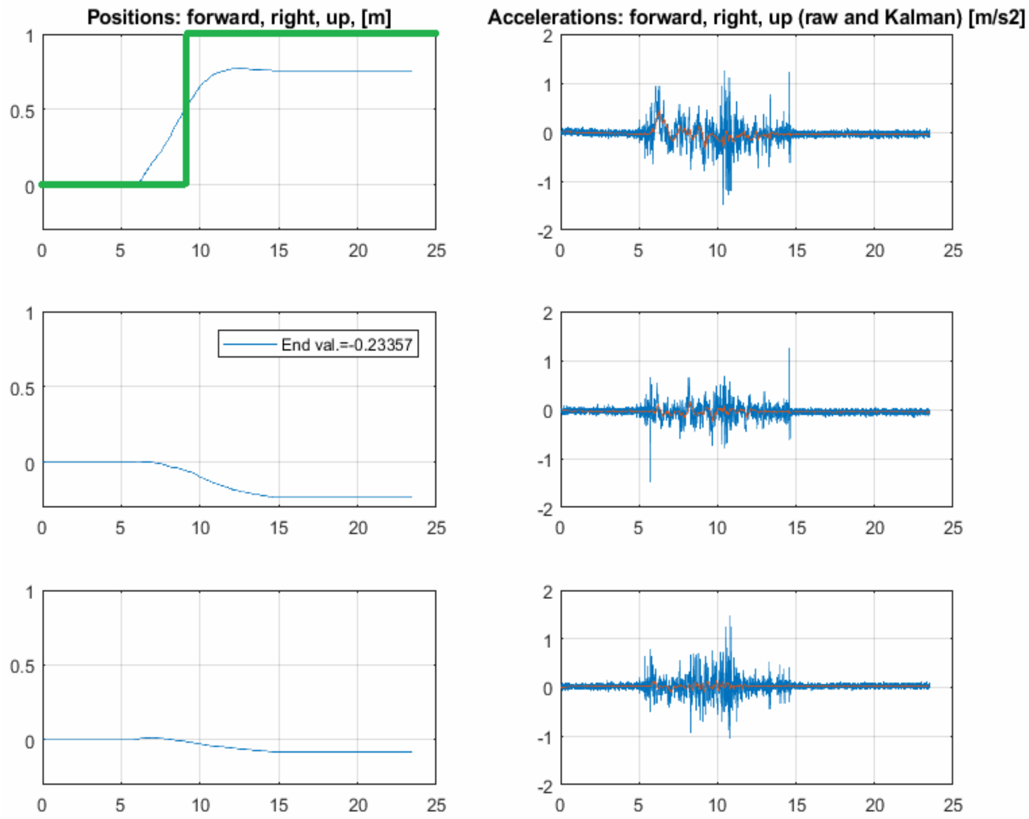
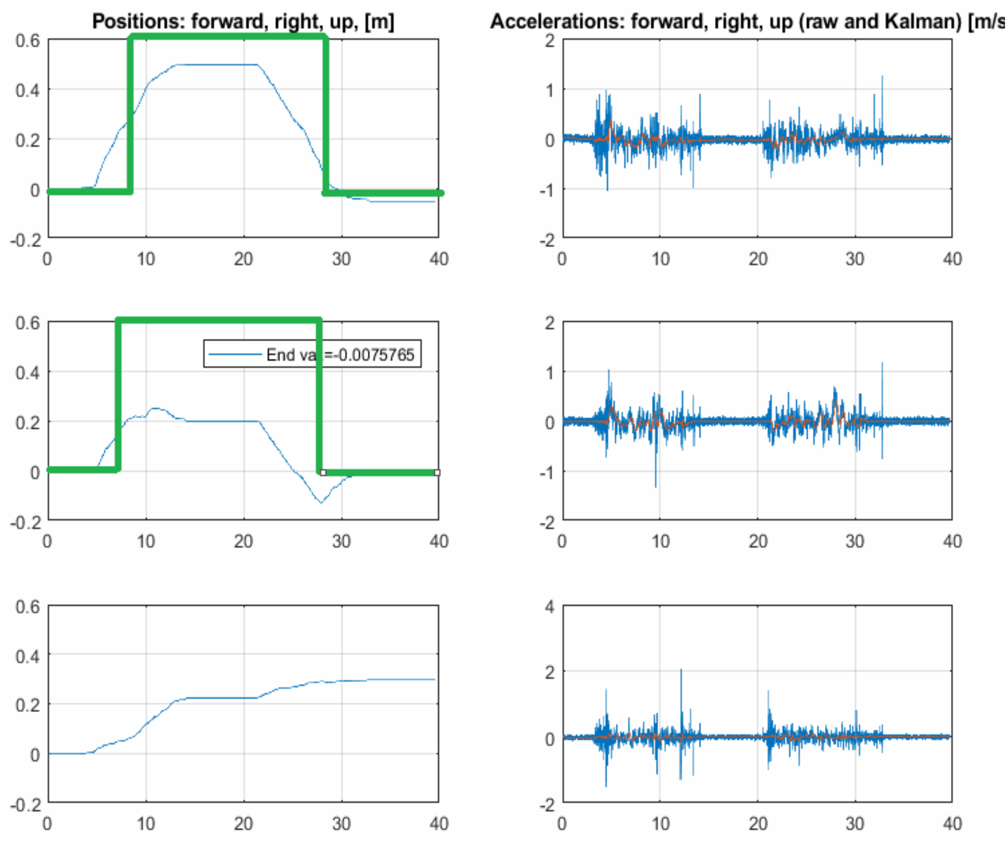


Fig. 3. Forward moving on 1 meter in horizontal plane (VR gear IMU)



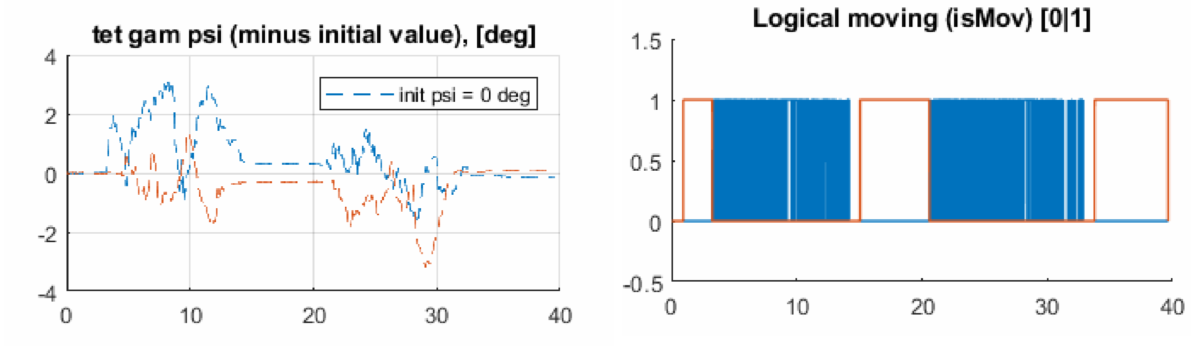


Fig. 4. Forward and back diagonal moving on 1 meter in horizontal plane (VR gear IMU)

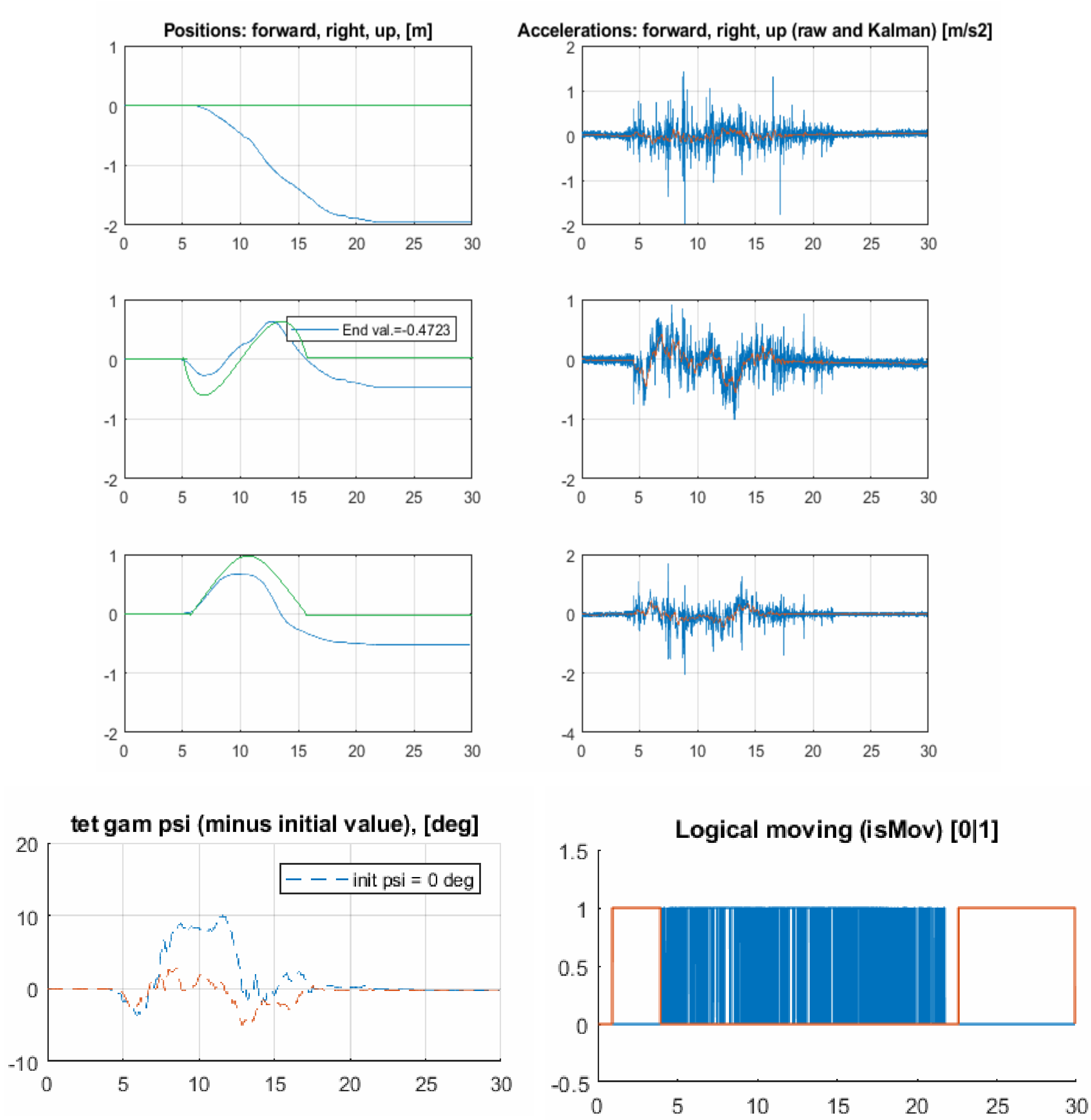


Fig. 5. Circle moving in vertical plane

The result is confirmed a possibility of the indoor measuring with acceptable sub meters accuracy. The algorithm will be refined by maintaining the accuracy of the motion direction determining, e.g. by means of a complementary filter, or by the calibration movements using.

This allows the determining the movement of unoccupied moving coordinates. Another suggestion is to use the added ultrasonic speed sensor on VR Gear. The overall dimensions of VR Gear allow the using of the ultrasonic speed sensor.

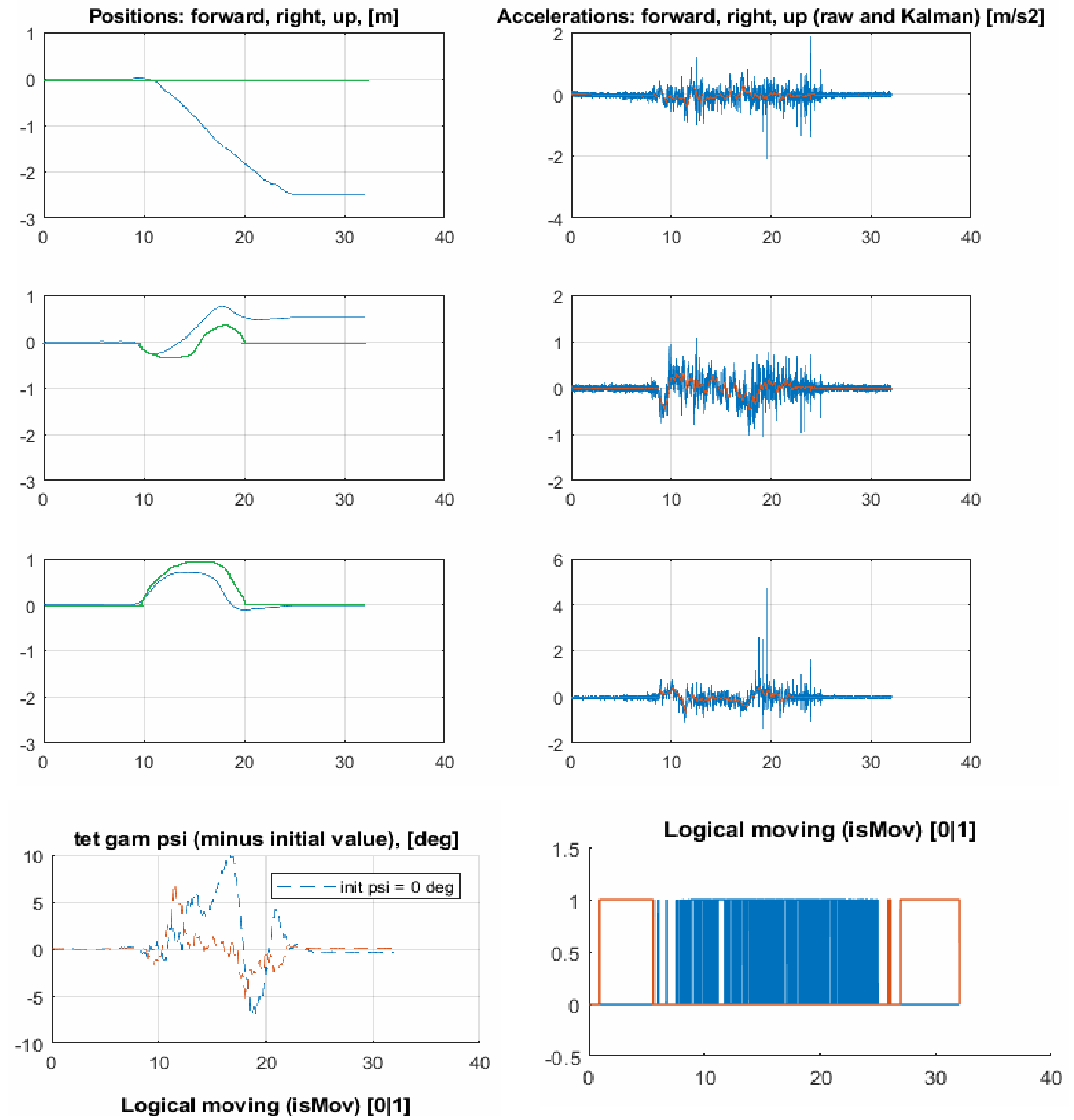


Fig. 6. Angular moving in vertical plane

References

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