2D Position Measurement with optical laser mouse sensor

Michal Bachratý
Slovak University of Technology in Bratislava

2D POSITION MEASUREMENTS WITH OPTICAL LASER MOUSE SENSOR

Michal Bachratý[1] – Milan Žalman[2]

ABSTRACT: Laser optical mouse is low cost solution for accurate computer cursor positioning today's. Concept of mouse position sensor data evaluation and possibility to determine position in two axes is not well-known. This article explains laser optical mouse sensor principle and presents measurements on sensor ADNS6010, especially precision, speed and reliability.

Key words: 2D position sensor, ADNS6020 measurements, optical mouse principle

1. INTRODUCTION

Optical mouse is based on digital image capturing of ground base with BW CMOS sensor. Optical sensor computes differences between two captured images followed one after another (figure 1) [1]. DSP algorithm computes size of image movement from significant image region. Figure 1 show two images captured from image sensor one after another. Right image is shifted 5 pixel right and 1 pixel down from the left one. Sensor capturing frequency must be adequate so that sensor is able to register high speed movement. Position can be determined only on surfaces with sufficient number of details [2]. Glossy and clear surfaces with low surface details are not suitable surfaces for position determination.

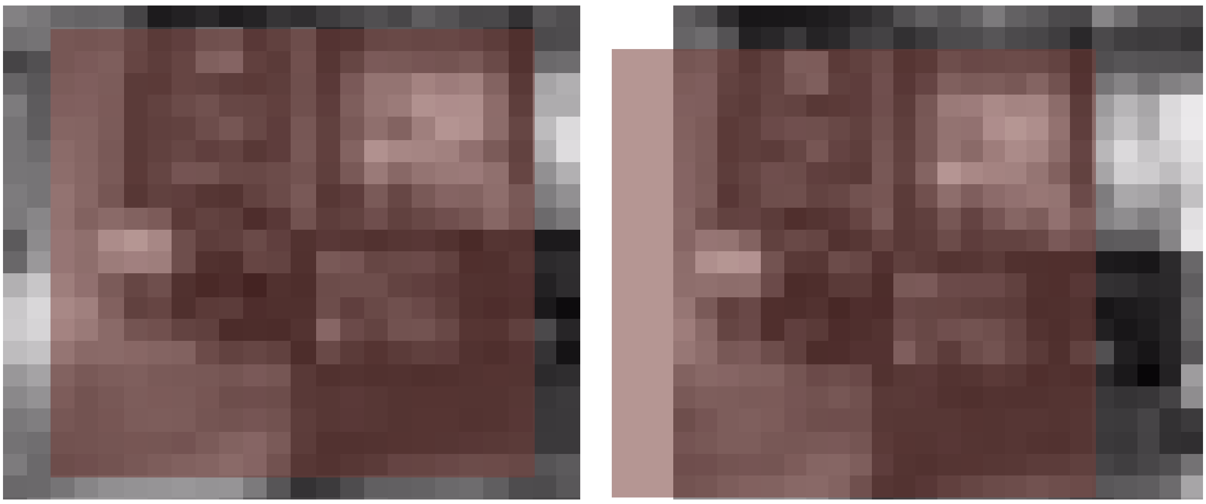

Figure 1 Surface pictures captured from optical mouse one after another. Colored frame represent same surface region

[1] **Michal, Bachratý, Ing., ÚRPI FEI STU Ilkovičova 3, 812 19 Bratislava, michal_bachraty@stuba.sk**
[2] **Milan, Žalman, prof. Ing. PhD., ÚRPI FEI STU Ilkovičova 3, 812 19 Bratislava, milan.zalman@stuba.sk**

2. LASER OPTICAL MOUSE

Modern optical mouse use laser diode to light under layer surface. Laser beam create concentrated light flux stronger than LED can create. Because high light flux, it is possible to create sensor with smaller pixel area and bigger number of pixels. Current laser optical mice contain sensors with resolution from 2000CPI (counts per inch) with 7200 fps to 4000CPI with 1000 fps. Laser lighting enables using lot of different types of under laying surfaces. One of the laser optical mouse sensors is ADNS6010. This sensor contains 30x30 pixel array, DSP controller and SPI interface. Sensor resolution can be 12.7 μm (2000CPI) or 15.875 μm (1600CPI) for one data bit. Original sensor documentation [3] claims that sensor can capture movement with 1143m/s and 20G acceleration without lack of step. Sensor communication is based on SPI (Serial peripheral interface) and sensor configuration is realized by configuration registers. Start sequence contains DSP algorithm for movement recognition, which must be downloaded to sensor before its using. Maximal length of algorithm can be 1986 bytes. Communication interface runs on 2MHz. Because lot of data must be transferred, one special command (Motion Read) for speed up reading most used data is embedded in sensor. Motion read command reads 7 registers Motion, Delta_X, Delta_Y, SQUAL, Shutter_Upper, Shutter_Lower, Maximum_Pixel).

3. MEASUREMENTS OF THE SENSOR ADNS6010

For using sensor in control applications, dynamical and static sensor parameters must be investigated. Standard documentation for ADNS6010 sensor does not contain this parameter. These parameters were measured on two-axis planar stepper motor. This stepper motor has basic step 32 μm, maximal speed 120mm/s and acceleration 25500mm/s^2. First measurement investigates static sensor precision, especially holding value in idle state without movement and ability to catch movement on step response. Testing sequence was as follows: stepper motor moves one 32 μm step then reads data from sensor. Sensor gives only relative position concerning to last read data. Last sensor value was added to last summed value. Reference position was measured by dial test indicator. This sequence was executed 32 times at the whole length 1024 μm in one axis with. Figure 2 present measurements results. Blue path shows computed value from position sensor multiplied by constant stated in sensor documentation (12.7 μm/bit). Maximal measured position error was 144 μm. Because error was big, new constant for sensor resolution was computed. New resolution value 11.02 μm/bit was computed from sum of measured data at last position divided by distance moved by motor. Using by this constant, maximal measurement error decreases to 20.2 μm. Results are shown white blue path in figure 2.

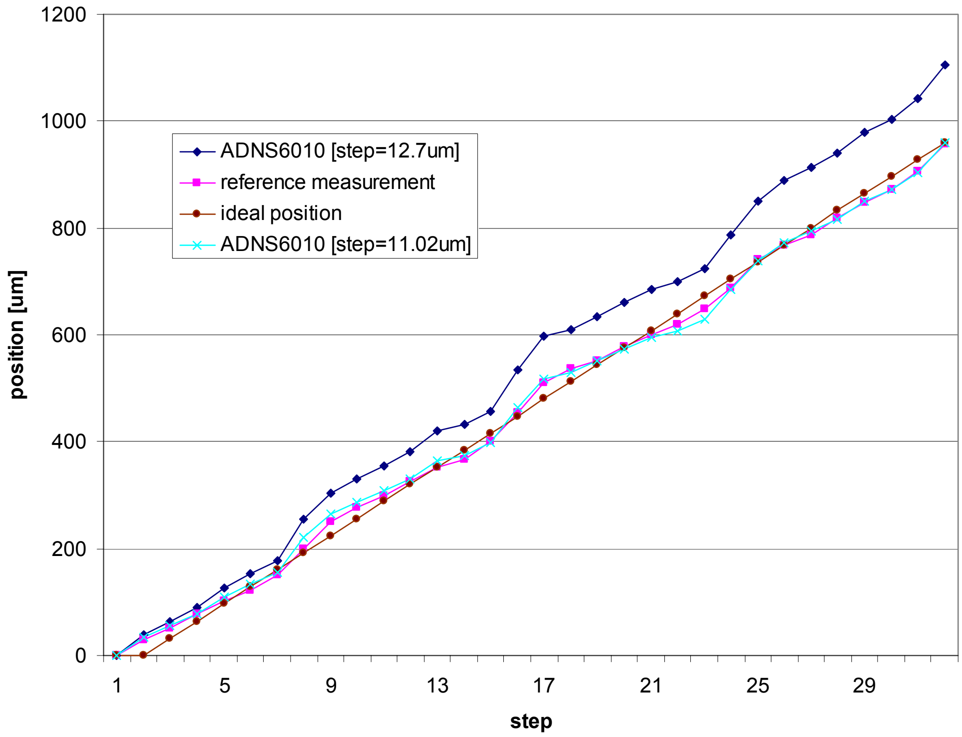

Figure 2 Precision measurements of ADNS6010 sensor

Real motor position and ADNS6010 sensor following error is shown in figure 3.

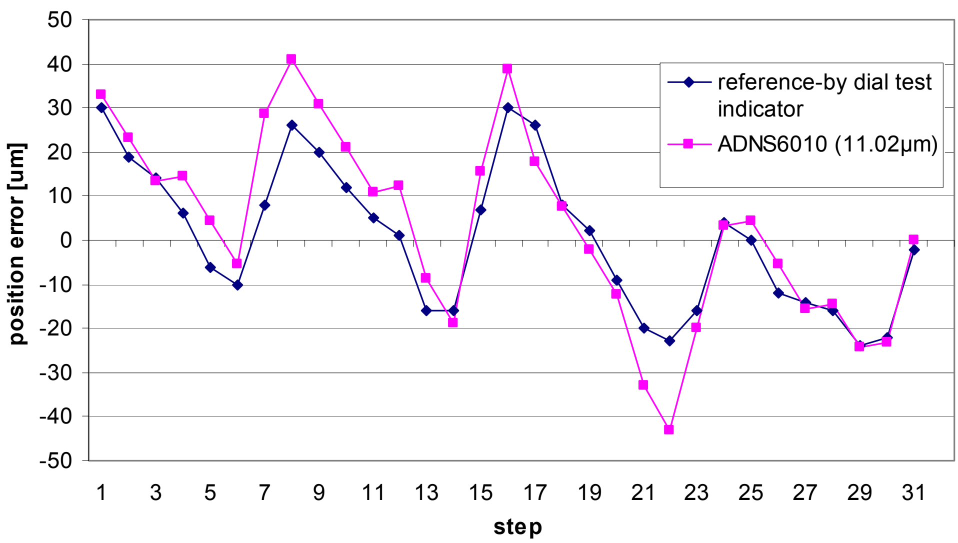

Figure 3 Real motor position vs. ADNS6010 data

Second measurements investigate sensor repeatability by different speed and acceleration. Real measurements are shown in table 1. Measurement sequence was as follows: Stepper motor with mounted sensor moved to required value (2016 µm) and then return back to start position. Different speed, acceleration and data reading speed were set. This sequence was repeated specific times. At the start position, sensor error was computed.

Table 1 ADNS6010 dynamic parameters measurements

Number of repeatings (line at 2016um a then back)	Sensor value after motor return to start position			Stepper motor speed [mm/s]	Stepper motor acceleration [mm/s^2]
	Sensor value	Computed position [um]	Mechanical sensor position [um]		
Data transfer rate: 2000 readings/s					
1	-3	-33.06	-3.8	20	25500
1	-11	-121	-1	20	25500
1	-5	-55.1	-1	20	2500
2	-4	-44.08	-1	20	2500
4	-17	-187.34	0	20	2500
Data transfer rate 5000 readings/s					
1	0	0	-1	60	2500
2	-5	-55.1	-1	60	2500
2	2	22.04	-1	40	10000

4. CONCLUSION

Sensor precision is influenced by some parameters like type of under laying surface, sensor acceleration, speed of data read. Measurements show that dynamic sensor parameters are not suitable for precise control applications. In the first set of measurements by readout speed 2000Hz was measurement error 187 µm. After increasing readout speed to 5000Hz readout speed, sensor precision was decreased to 55 µm. This sensor is possible to use with cooperating sensor which reset sensor error every defined period. After then well position error can be achieved, but new measurements must be done.

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