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Full Parameters Calibration for Low Cost Depth Sensors

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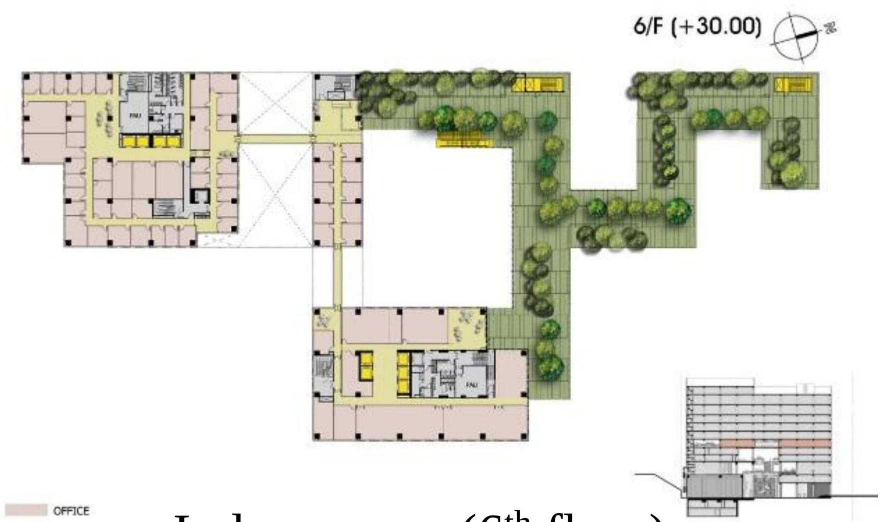
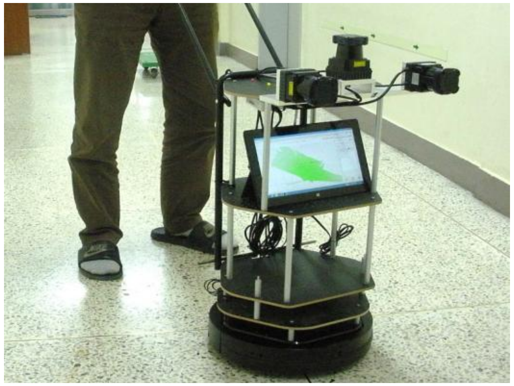
3D modeling for indoor environment



Indoor space (6th floor)

TLS



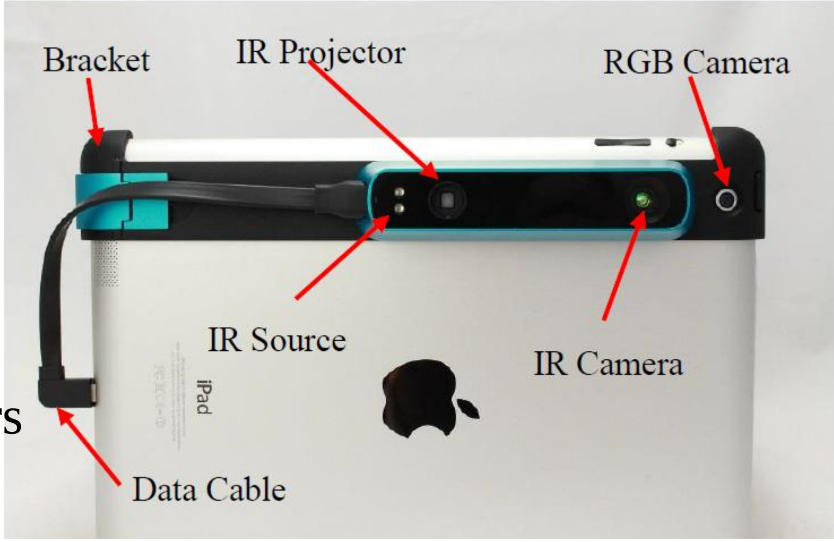
LLS/ cameras

RGB-D KINECT

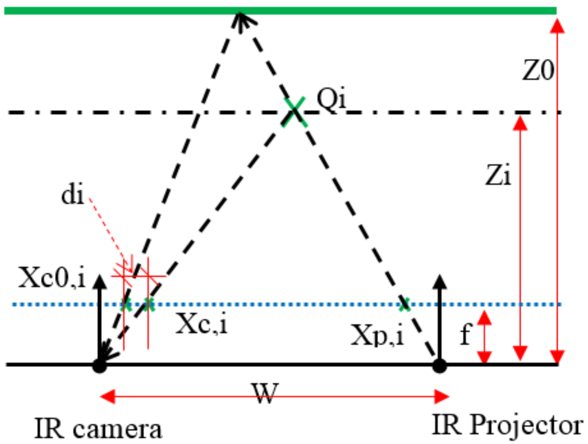
RGB-D Structure Sensor

http://openbuildings.com/buildings/the-hong-kong-polytechnic-university-phase-8-development-profile-4953/media#

RGB-D sensor concepts (Structured light)



- Components
  - IR camera
  - IR projector
  - RGB (optional)
- Physical manufacture elements/parameters
  - Focal lengths and principal points of cameras
  - IR-RGB cameras baseline
  - IR camera and projector baseline
  - Standard depth for IR projector
- Theoretical parameters/models
  - Distortion parameters
- Manufacture equation (concept of working) relation between measurement and output



$$Z_i = \frac{1}{a + b.d_i^n} \quad a = {}^{1}\!/_{Z_0} + {}^{\beta}\!/_{f.w} \;\&\; b = {}^{\alpha}\!/_{f.w}$$

Objectives

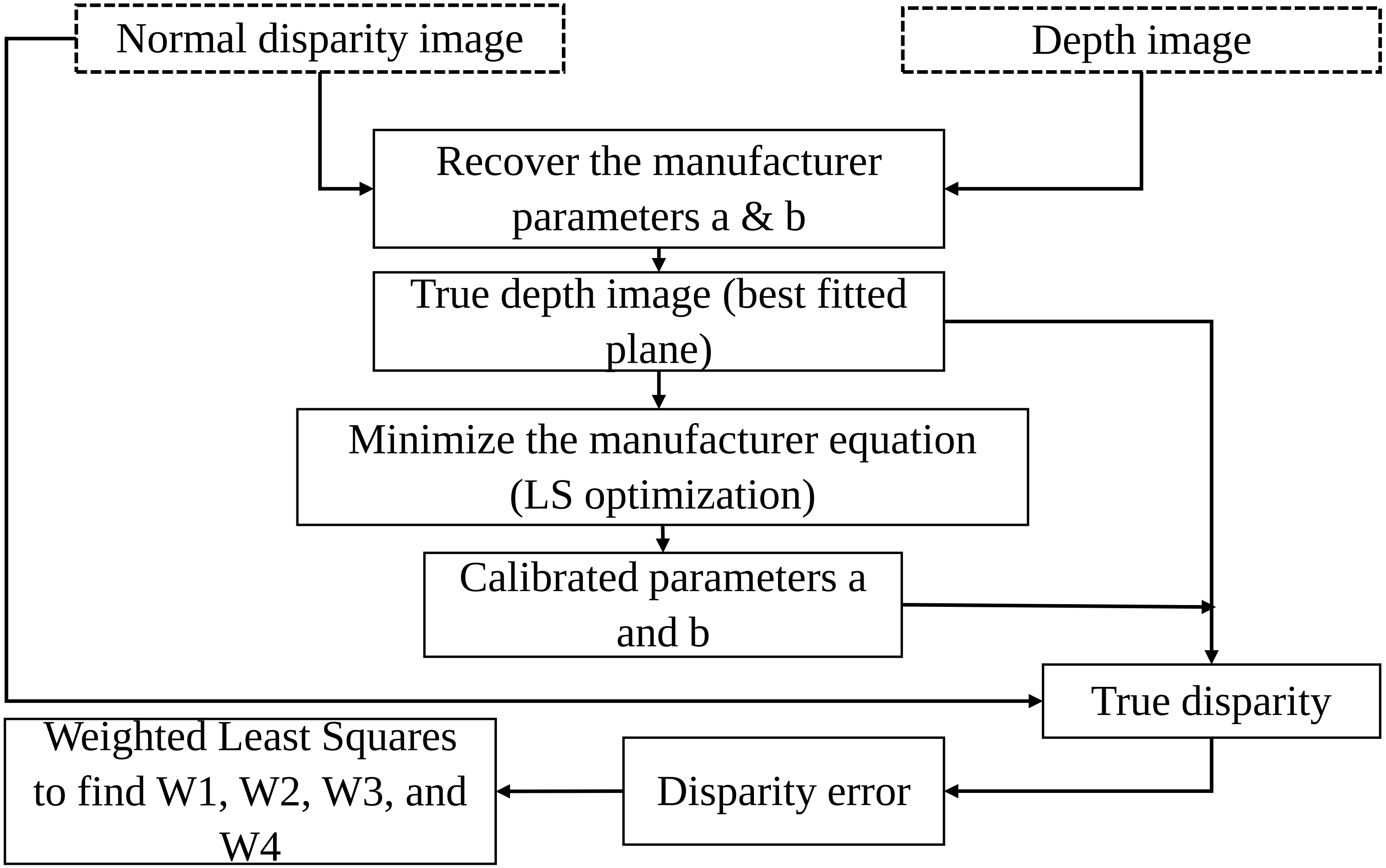
- Dynamic calibration method to achieve accurate depth data from RGB-D sensors
  - Manufacture parameters (a, b)
  - Distortion model for depth sensor
  - Systematic error modelling for depth data

Methodology

- Methodology was divided into two main parts:
  - Calibrated physical parameters for depth sensor
  - Applying a new error model which deals with distortion and systematic error
- The distortion model equation is stated as:

$$disp.error_i = \begin{bmatrix} W1 \\ W2 \\ W3 \\ W4 \end{bmatrix}^T \begin{pmatrix} 3*Td_i*(2*x_i - Td_i) \\ 2*y_i*Td_i \\ x_i*\left(Td_i*(2*x_i - Td_i)\right) \\ x_i*\left[(Td_i*(2*x_i - Td_i) + 2*(x_i - Td_i)^2)*(Td_i*(2*x_i - Td_i)) + 2*y_i^{\,2}*Td_i*(2*x_i - Td_i)\right] \end{pmatrix}$$

Methodology cont.



Experiments and Results

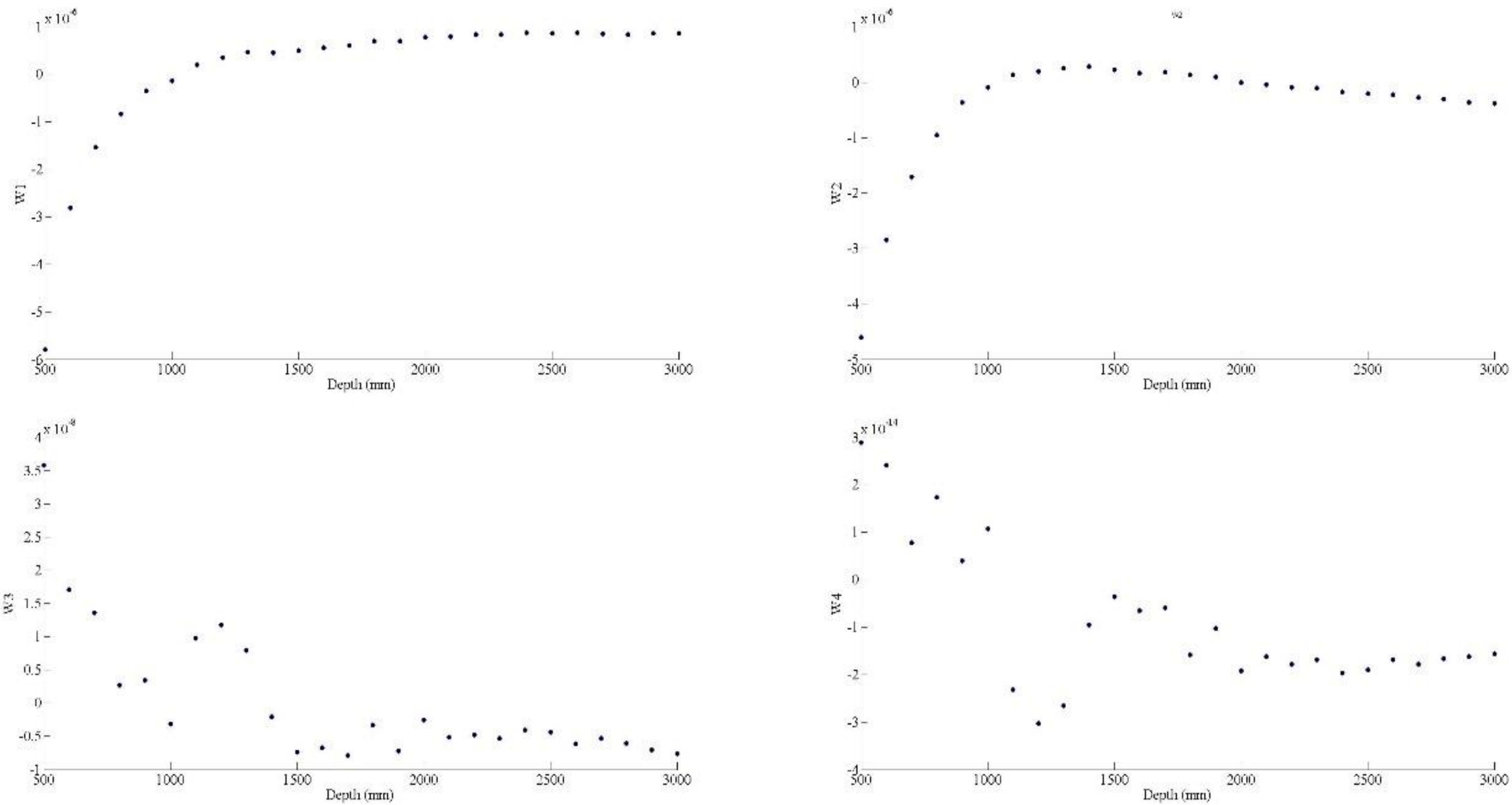
- Data collection:
- Structure sensor was used to collect two sets of data.
  - First set to verify our calibration methodology which give us the calibrated factors a and b and the distortion set of parameters w's
  - Second set is to examine the performance of applying our full set of parameters in real time

Experiments and Results cont.

The calibrated and the manufacture parameters for structure sensor

Structure Sensor	Manufactured value		Calibrated value	
	a	b	a	b
	-3.38649E-06	3.82538E-03	-3.39008E-06	3.82836E-03

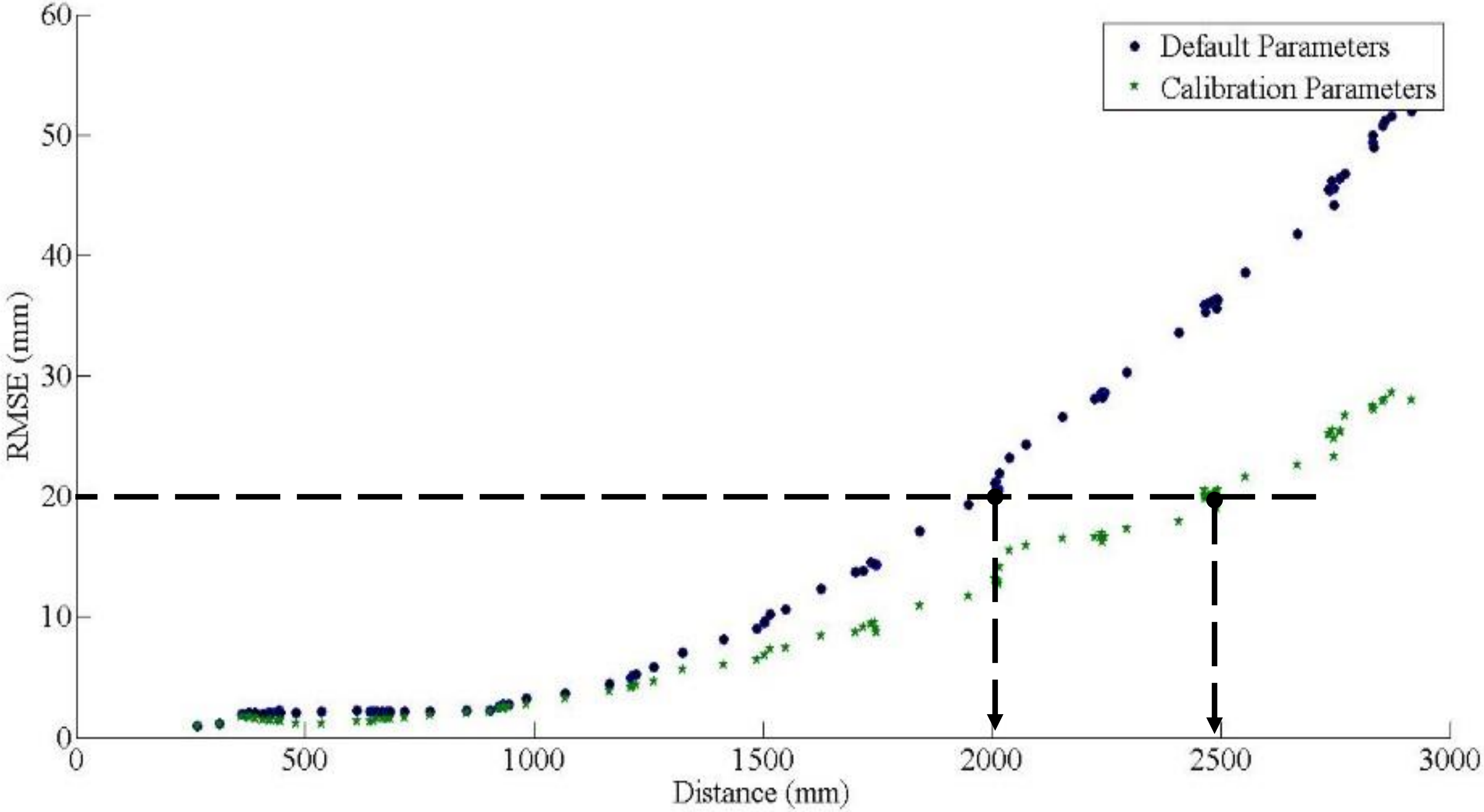
Experiments and Results cont.



Distortion model factors results

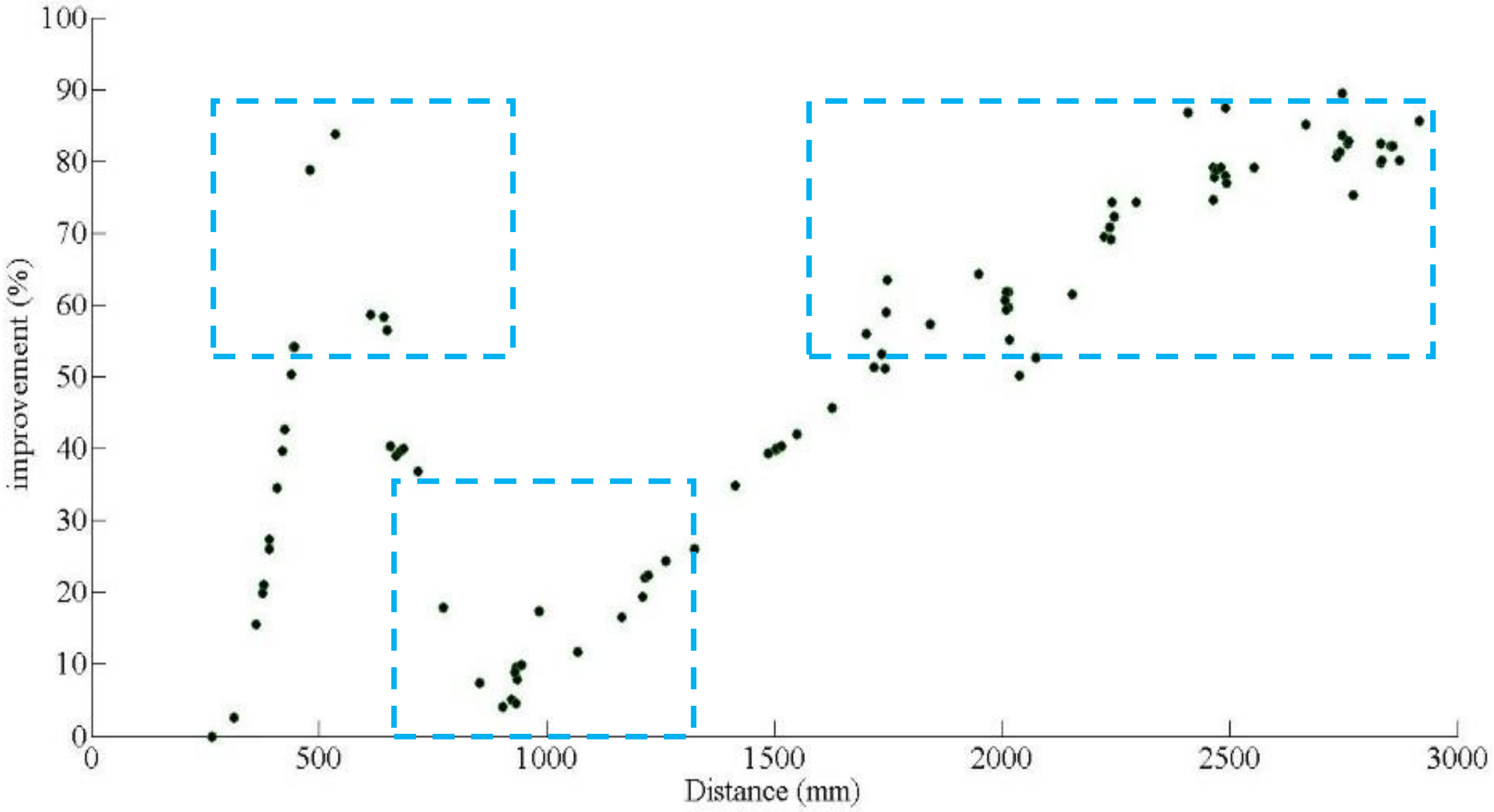
Experiments and Results cont.

- The error model impact on real time data captured by structure sensor.



Experiments and Results cont.

- The error model impact on real time data captured by structure sensor.



Conclusions

- Low cost depth sensors have attracted broad attention from many disciplines such as computer vision, robotics navigation, surveying, BIM, and smart cities.
- The accuracy of such sensors is highly depend on the calibration of the manufacture parameters as well as the error model and the distortion of the sensors which implemented in depth sensor.
- A new model for distortion and systematic errors was proposed and examined for structure sensor which treated as latest mobile low cost depth sensor released in the commercial market.

Conclusions

- The results show an effective performance for error model and a significant improvement in depth precision for far and near range (around 80%), and noticeable improvement for normal working range (around 20%).
- The extended work for this research will deal with the applicability of the distortion model with other low cost depth sensors released on the market (e.g. KINECT) and check the reliability and stability of the error model.

THANK YOU FOR YOUR ATTENTION

ANY QUESTIONS …?