

# **3D Modeling Using STRUCTURE Sensor**

July 5 2017

Jungwon Kang

# Contents

---

- 1. Introduction
- 2. STRUCTURE Sensor
- 3. 3D Modeling from Scanning
- 4. Conclusion

# 3D Scanning for Modeling

- **Modeling of Indoor Space, Object-of-Interest, and Many Other Things**



\*source: [https://youtu.be/IEeW\\_byzB8Y](https://youtu.be/IEeW_byzB8Y)

# Commercial 3D Scanners

- **Many Commercial Ones, But Still Expensive (for Personal Use)**

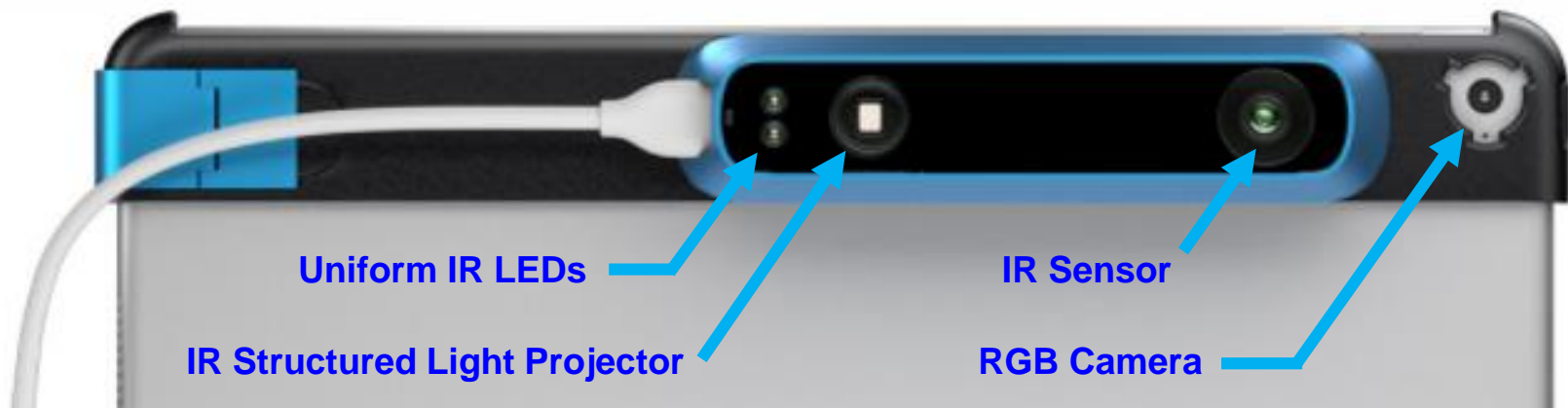


**Matterport Pro2 3D Camera (MC250):**

USD 3995 [Device] + USD 100/Month [Data Processing Service]

# STRUCTURE Sensor (1/3)

- **STRUCTURE Sensor: A Consumer-Grade 3D Scanner**
  - Developed by [Occipital](#) Inc. in 2014
  - Small, lightweight IR-based 3D scanner
  - Provides RGB-D data (when combined with iPad RGB camera)
  - USD 379



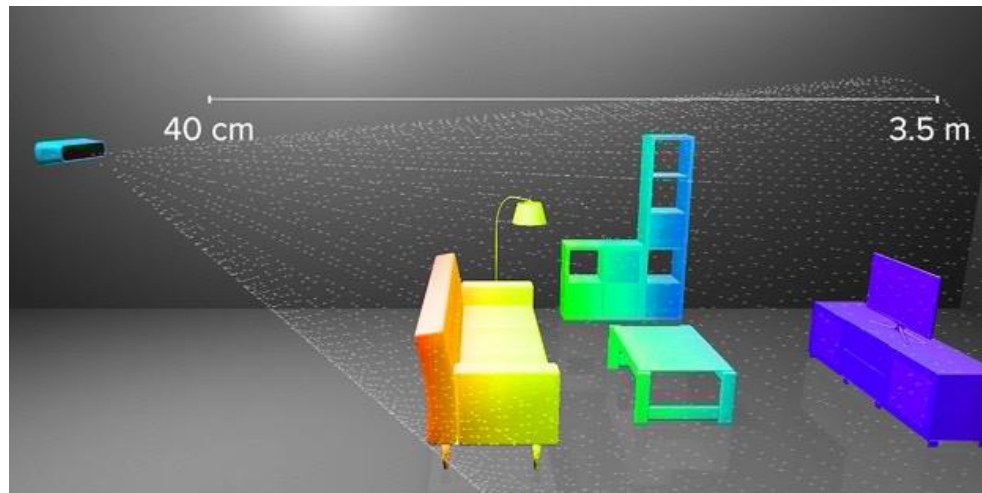
# STRUCTURE Sensor (2/3)

### ■ Specification

Length x Width x Height	119.2 mm x 27.9 mm x 29 mm
Weight	99.2 grams
Sensing distance	40 cm ~ 3.5 m
Precision	1% of measured distance
Resolution	VGA(640 x 480) / QVGA (320 x 240)
Framerate	30 / 60 frames per second
Battery Life	3-4 hours of active sensing
Field of View	58° (Horizontal), 45° (Vertical)



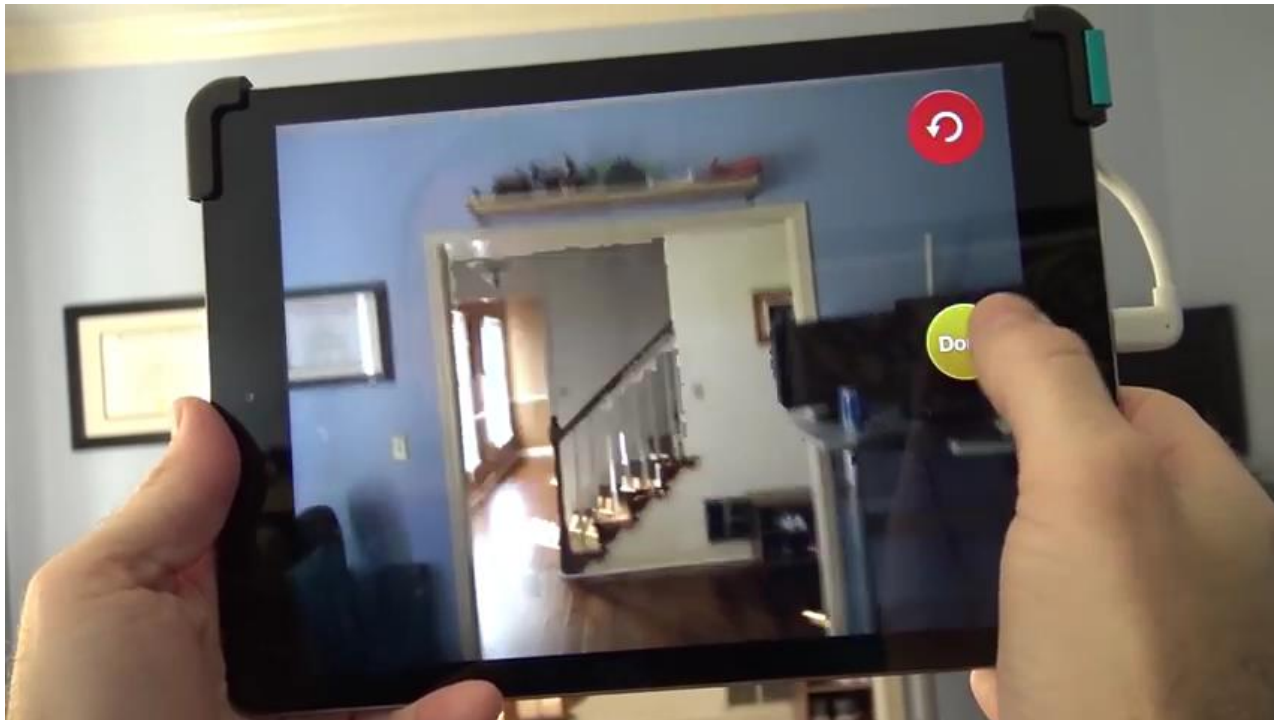
**STRUCTURE sensor on a iPad**



# STRUCTURE Sensor (3/3)

### ▪ What You Can Do Using STRUCTURE Sensor

- Scanning indoor space (using *Room Capture* app), object-of-interest (using *Scanner* app)
- Augmented reality (using *Fetch* app)

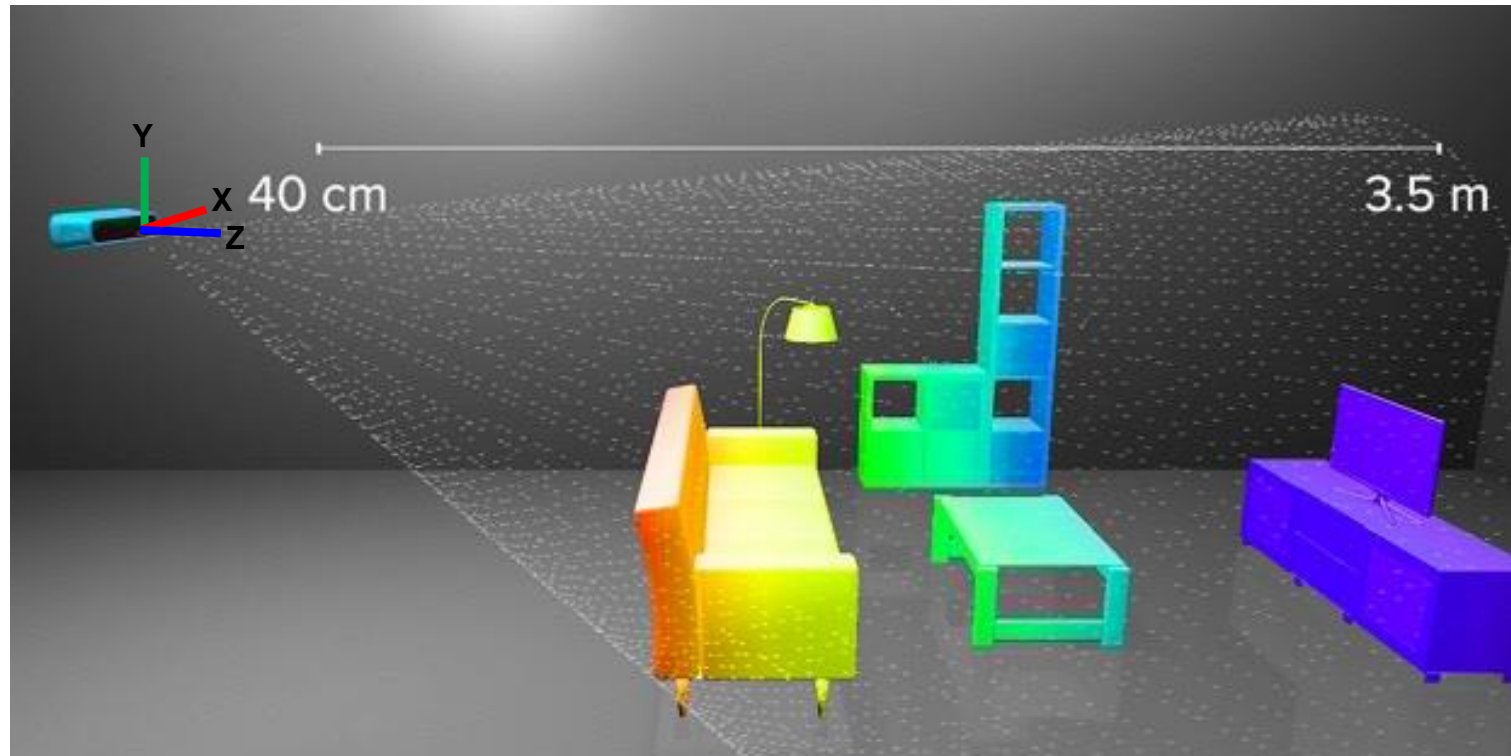


\*source: <https://youtu.be/f7wTrLUERHE>, [https://youtu.be/nFyT2q8f\\_i4](https://youtu.be/nFyT2q8f_i4)



# 3D Modeling from Scanning (1/6)

- **Point Cloud Generation (At a certain Frame)**
  - Generation of a set of points wrt a local sensor coordinate at a certain frame

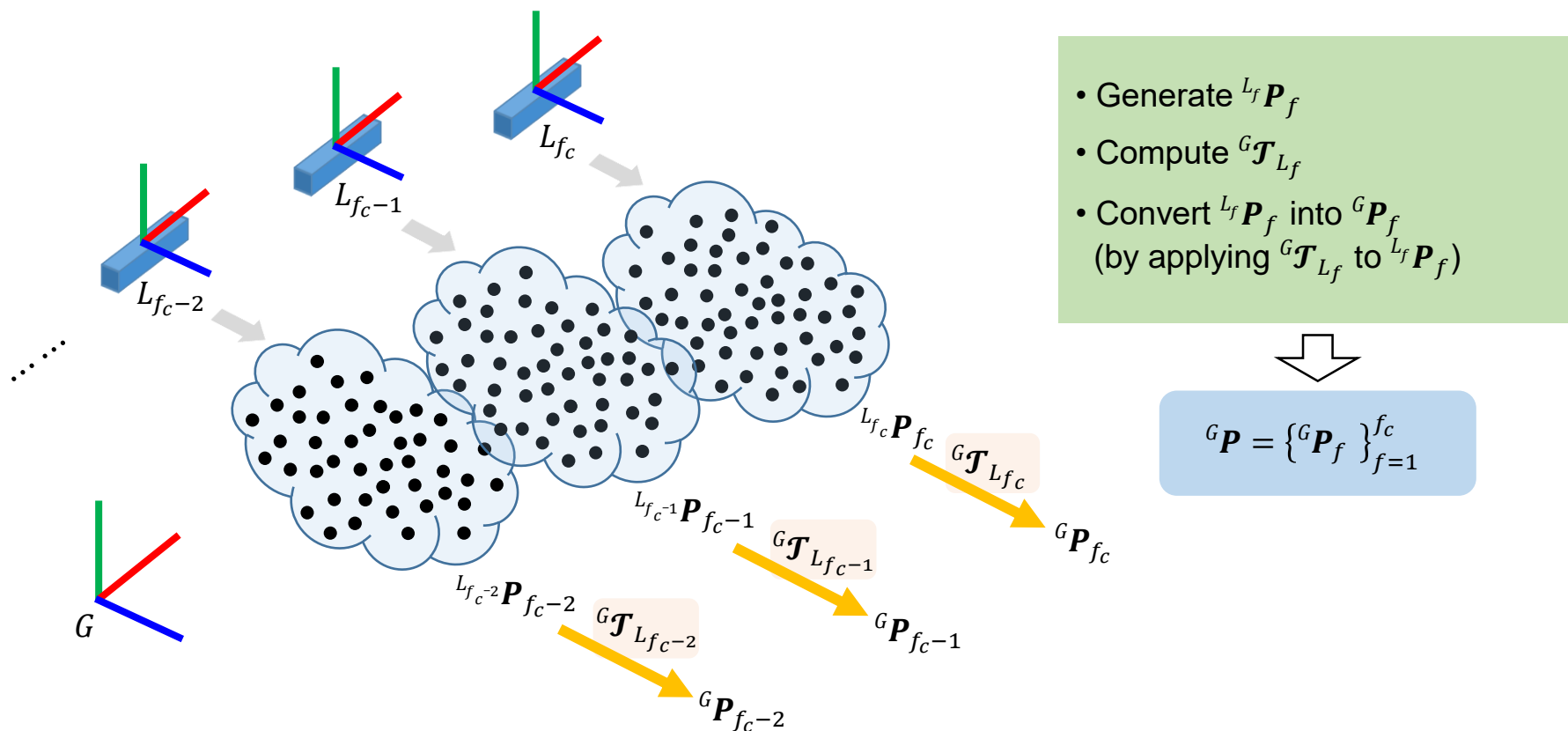




## 3D Modeling from Scanning (2/6)

### ■ Concatenation of Point Cloud at Each Sensor Pose

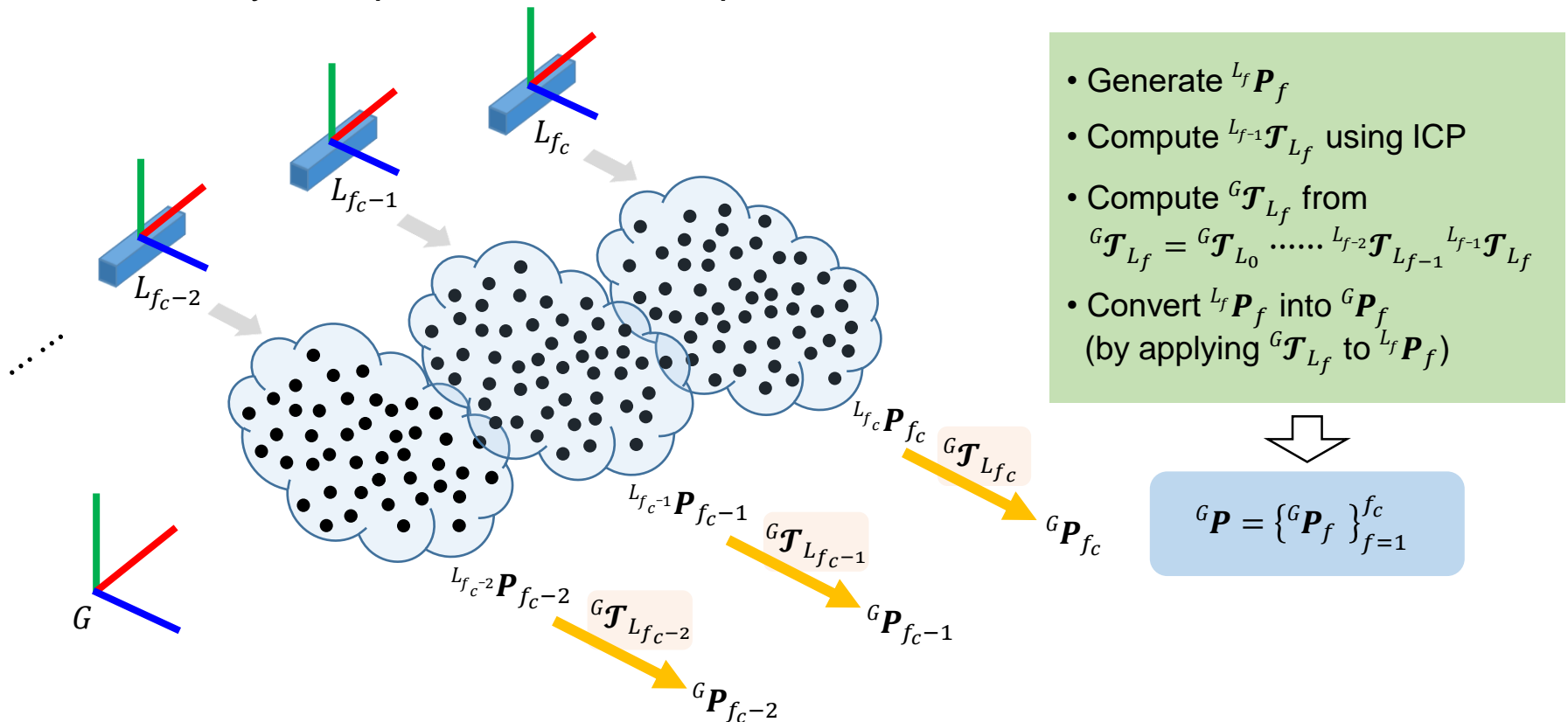
- Formally, called **point cloud registration**
- Registering point cloud wrt a local sensor coordinate in a global coordinate



## 3D Modeling from Scanning (3/6)

### Point Cloud Registration Based on Two Consecutive Frames

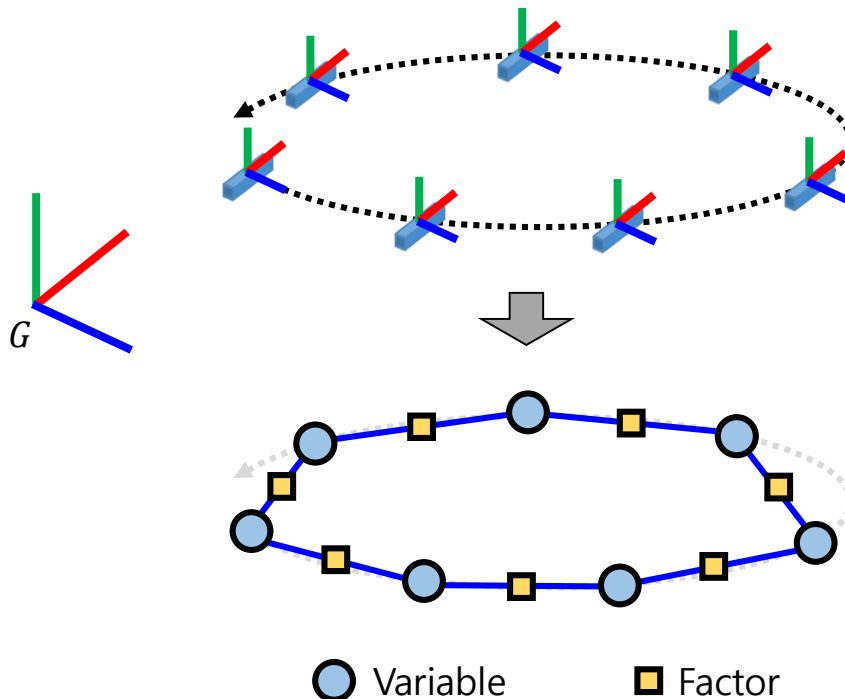
- ICP (**Iterative Closest Point**) algorithm for finding a transformation that best aligns one point cloud wrt the other point cloud.
- Easy to implement, but error-prone due to accumulated error.



## 3D Modeling from Scanning (4/6)

### ■ Point Cloud Registration Based on All Frame Adjustment

- Formally, called **pose graph optimization**
- Using a **factor graph** where the *variables* are sensor poses to be estimated, and the *factors* are relative pose measurements between sensor poses
- Reducing the accumulated errors when a **loop closing** is detected.

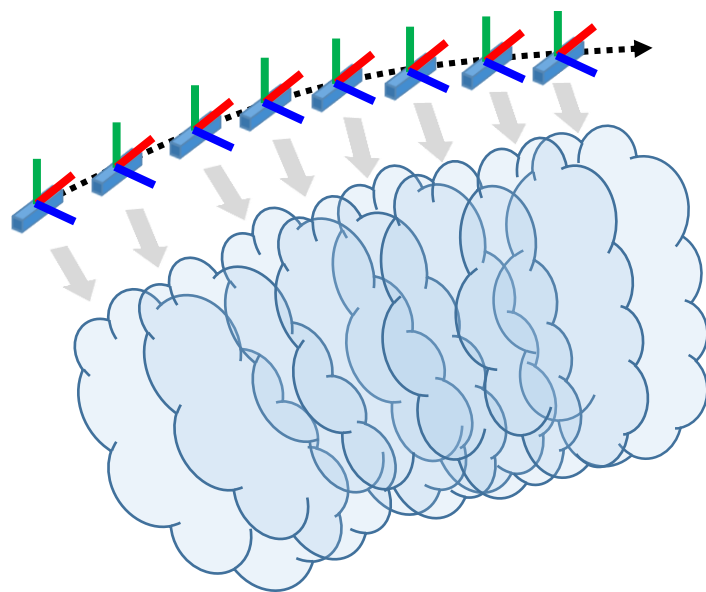


- Generate  ${}^{L_f}\mathbf{P}_f$
- Compute  ${}^{L_{f-1}}\mathbf{T}_{L_f}$  using ICP
- Compute  ${}^G\mathbf{T}_{L_f}$  by solving
 
$$\mathcal{X}^* = \arg \min_{\mathcal{X}} \frac{1}{2} \sum_f \|h_f(\chi_f) - z_f\|_{\Sigma}^2$$
 where  $\mathcal{X}^* = \left\{ {}^W\mathbf{T}_{L_f} \right\}_{f=1}^{f_c}$ ,  $z_f = {}^{L_{f-1}}\mathbf{T}_{L_f}$
- Convert  ${}^{L_f}\mathbf{P}_f$  into  ${}^G\mathbf{P}_f$   
(by applying  ${}^G\mathbf{T}_{L_{f_c}}$  to  ${}^{L_f}\mathbf{P}_f$ )

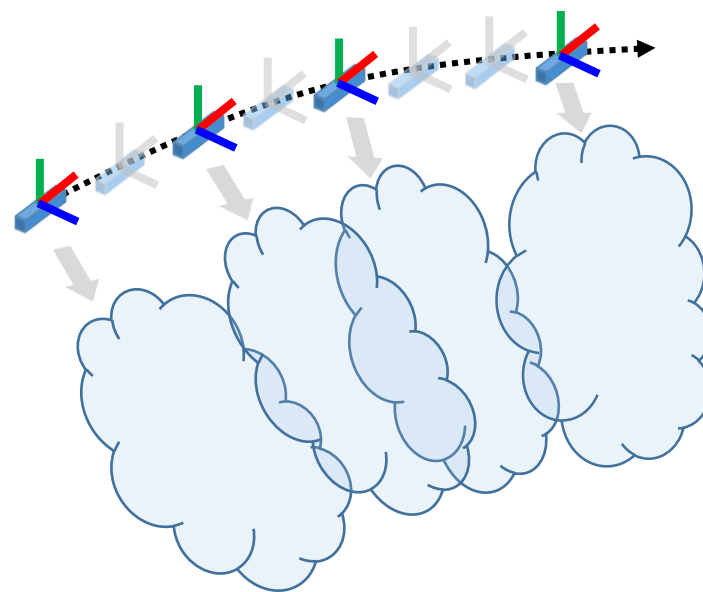
$${}^G\mathbf{P} = \left\{ {}^G\mathbf{P}_f \right\}_{f=1}^{f_c}$$

## 3D Modeling from Scanning (5/6)

- Using **Keyframes** for Pose Graph Optimization
  - Selecting informative frames as *keyframes* for efficient operation with low data redundancy
  - Using a factor graph for sensor poses at keyframes



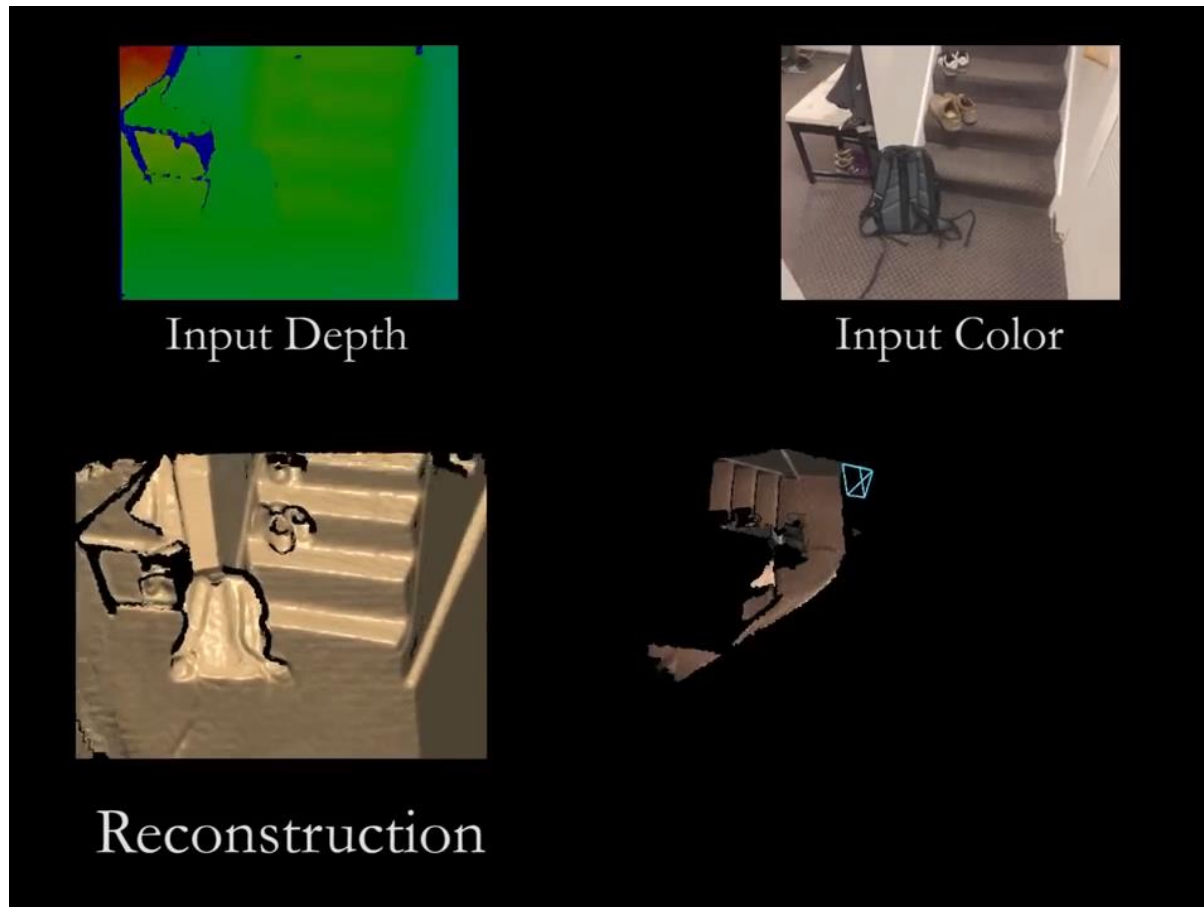
Using all frames



Using keyframes

## 3D Modeling from Scanning (6/6)

- **Point Cloud Registration Based on All Frame Adjustment**



[A. Dai, 2017]

\*source: <https://youtu.be/kelirXrRb1k>

# Conclusion

### ▪ **STRUCTURE Sensor**

- A consumer-grade 3D scanner (for personal use)
- Provides several apps for modeling of indoor space, object-of-interest, and augmented reality.

### ▪ **3D Modeling from Scanning**

- Keywords: point cloud registration / ICP / pose graph optimization / keyframes

### ▪ **Some Notes on Your Practice**

- See how certain materials affect scanning.
  - ✓ Tip: Try scanning a mirror or a glass.
- See when generated 3D model is inaccurate.
  - ✓ Tip: In order to enhance the quality of 3D model, please simplify your own motion while scanning.