Handling ROS tutorial

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http://mrl.isr.uc.pt/events/iros2012tutorial/

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Visual Perception System within HANDLE EU project using ROS
Robots need visual 3D perception

Picture from http://thecorpora.com
Outline

- Depth measurement techniques: Kinect
- ROS/Kinect integration
- System for robotic visual perception
- Interfacing with an object SQL database
- ROS vision nodes within HANDLE EU project
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Depth measurement techniques

Depth Measurement Techniques

Microwaves
Light Waves
Ultrasonic Waves

Triangulation
Structured light
Time-of-Flight
Laser Scan

Kinect
Asus Xtion
PrimeSense

Picture from the Artist Audrey Penven
Principles of Kinect

- 640x480 px @ 30 fps
- Operation range:
  - 0.8m~3.5m
- Depth resolution [1]:

![Diagram of Kinect components]

**IR Laser projector**
\[ \lambda = 830\text{nm} \]

**RGB camera**

**IR camera**

![Graph showing theoretical random error and depth resolution vs distance to plane (cm)]

- *Theory* random error
- Depth resolution

*Picture from iFixit*
How Kinect works?

- Libraries: OpenNI, libfreenect y Kinect SDK
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OpenNI in ROS

Picture from [3]

OpenNI

Middleware Components (e.g. Hand gesture tracking)

Hardware Device (sensor)

Application (Game, TV Portal, Browser, etc.)

Middleware Component A
Middleware Component B
Middleware Component C

ROS.org

About | Support | answers.ros.org

http://www.ros.org/wiki/

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ROS/Kinect integration

OpenNI

openni_tracker
openni_camera
openni_kinect
openni_launch

image_pipeline

vision_opencv

OpenCV Overview:
- General Image Processing Functions
- Geometric descriptors
- Image Pyramids
- Segmentation
- Features
- Camera calibration, Stereo, 3D
- Transforms
- Machine Learning: Detection, Recognition
- Tracking
- Matrix Math
- Fitting

OpenNI libraries:
- openni_kinect
- openni_tracker
- openni_camera
- openni_launch

Perception PCL:
- perception_pcl
ROS image and OpenCV image

- **OpenNI:**
  - RGB format

- **OpenCV:**
  - BGR format

- [http://www.ros.org/wiki/cv_bridge/Tutorials/UsingCvBridgeToConvertBetweenROSImagesAndOpenCVImages](http://www.ros.org/wiki/cv_bridge/Tutorials/UsingCvBridgeToConvertBetweenROSImagesAndOpenCVImages)
ROS/Kinect integration

- Start the Kinect driver:
  - roslaunch openni_launch openni.launch

- Reconfigure camera parameters:
  - rosrun dynamic_reconfigure reconfigure_gui

- Visualize the images:
  - rosrun rviz rviz
    - If you have problems with starting rviz, remove files in ~/.rviz/.

- Add a PointCloud2 View: XYZRGB point cloud
  - For topic camera/depth_registered/points
ROS/Kinect integration
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Calibrating a Kinect to your robot

TF Hands-on #2 Session

Checkerboard detector
ROS Examples

System for robotic visual perception

- Segmentation, recognition, pose estimation, object tracking…
- ROS stacks:
  - http://www.ros.org/wiki/iap: tracking and segmenting visual features
  - PCL and OpenCV.
Segmentation

- Table detection using RANSAC
Object recognition and pose estimation

Picture from PCL
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Interfacing with a SQL database

- Installed:
  - A PostgreSQL server.
  - A database: restored from the provided backup file.
  - Iros_st2_database package: functions for interfacing with a specific SQL database.
  - Iros_st2_database_msgs package: ROS API.

- Updated model_root:

```sql
<table>
<thead>
<tr>
<th>variable_name</th>
<th>variable_id [PK]</th>
<th>variable_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODEL_ROOT</td>
<td>2</td>
<td>/home/handle/ros/iros_st2_database/database</td>
</tr>
</tbody>
</table>
```
SQL database: schema

- Starting point: household_objects_database
  - www.ros.org/wiki/household%20objects
SQL database: usage

- Launch the local server:
  - roslaunch iros_st2_database iros_st2_database_server.launch

- Provided ROS services:
  - iros_st2_hdb/get_list_by_acquisition_method: list of models available in the database by given an acquisition method
  - iros_st2_hdb/delete_model: deletes a model
  - iros_st2_hdb/download_model: gets a 3D mesh
  - iros_st2_hdb/insert_model: stores a model in the database
  - iros_st2_hdb/update_model: updates a stored model
SQL database: ROS Services

- Get list by acquisition method:
  - rosservice call iros_st2_hdb/get_list_by_acquisition_method <name>
SQL database: ROS Services

- Download a mesh from the database:
  - rosservice call iros_st2_hdb/download_model <scaled_model_id>

- Insert a model in the database, copying the files to a location specified by the model_root.
  - rosservice call iros_st2_hdb/insert_model <model_name> <acquisition_method> <maker> <description> <barcode> <geometry_filename> <color_image_filename>
    - E.g.: rosservice call iros_st2_hdb/insert_model camera iros_st2 "" "" "" /iros_st2_database/database/examples/camera.model/mesh.ply /iros_st2_database/database/examples/camera.model/view0000/raw/color.png
SQL database: ROS Services

- Delete a model from database:
  - rosservice call iros_st2_hdb/delete_model <scaled_model_id>

- Update a model from database:
  - rosservice call iros_st2_hdb/update_model <original_model_id> <model_name> <acquisition_method> <maker> <description> <barcode> <geometry_filename> <color_image_filename>
    - E.g.: rosservice call iros_st2_hdb/update_model 9623 camera iros_st2 unknown "" "" "" ""

```sql
CONSTRAINT scaled_model_pkey PRIMARY KEY (scaled_model_id),
CONSTRAINT scaled_model_original_model_id_fkey FOREIGN KEY (original_model_id)
    REFERENCES original_model (original_model_id) MATCH SIMPLE
ON UPDATE CASCADE ON DELETE CASCADE
```
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HANDLE: Kinect/robot calibration

- Shadow Hand
- Shadow Arm
- Kinect Camera
- ATI Force/Torque Sensors
- Kinect Camera
- Calibration

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HANDLE: reconstruction using a single view

Color and Depth Image

3D Scene Points

Table-top Object Detector

Voxel filling by extrusion

Consistency Check

Color-based Model Refinement

Poisson Reconstruction

3D Object Model
HANDLE: reconstruction using a single view
**HANDLE: Object recognition and pose**

- **Viewpoint Feature Histogram (VFH) descriptor** used for matching and recognition of point clouds [10]

- Recognition and 6D pose estimation for objects lying on a table:
HANDLE: Object recognition and pose

Object recognition and pose estimation using Handle software.
References

References

Thank you!

Questions/comments?