Principles of Robot Autonomy I

The Robot Operating System (ROS)

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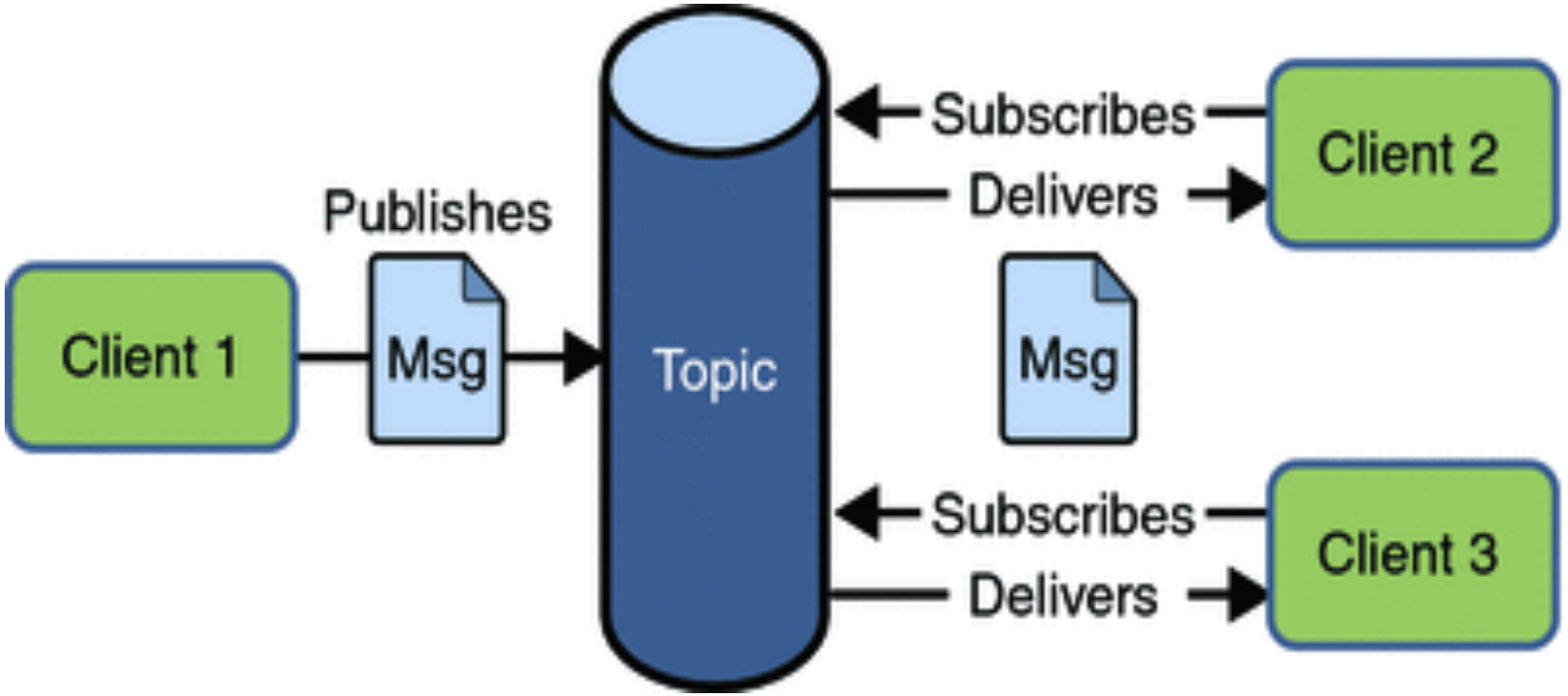
The Pub/Sub design pattern

- Stands for Publish-Subscribe
- Each component (i.e. node) can:
  - *Publish*: send messages regardless of whether someone is listening
  - *Subscribe*: receive messages if anyone is sending them regardless of who

The Pub/Sub design pattern



Note: there are countless ways to IMPLEMENT pub/sub!

What is ROS?

- An implementation of a network-aware pub/sub* geared towards robotic applications
- Lots of open-source software shared by the community:
  - SLAM (gmapping, amcl)
  - Vision (OpenCV, PCL, OpenNI)
  - Arm Navigation (MoveIt)
  - Simulation (Gazebo)

The main components

- Nodes
  - talk to each other over topics (think chat rooms).
- Master
  - coordinates the whole thing
- Message types: abstraction away from specific hardware
  - Camera image
  - Laser scan data
  - Motion control

ROS Node

- A process (typically Python or C++) that runs some computation
- The “fundamental” building block
- Can act as a subscriber, publisher or both
- Nodes talk to each other over “topics”
- Run them using rosrun <package> <node>
- Initialize using rospy.init_node()

Note: nodelets are different. They are not individual processes, they share memory

ROS Master

- A process that is in charge of coordinating nodes, publishers and subscribers
- Exactly one of them running at any time
- Nodes will not be able to find each other without Master

Abstraction vs Implementation

- Pub/sub is only an **abstraction**, a way to think about the architecture of your software
  - Ex: Messages do NOT go through Master

A bit of networking…

- Two important environment variables:
  - ROS_MASTER_URI
    - The IP address of the computer running master
  - ROS_IP
    - The IP address of your computer

Getting help

- ROS wiki (http://wiki.ros.org/)
- Github
- Stack Overflow
- The Construct / Robot Ignite Academy
- Google :)

4.2 face_recognition

Recognize faces in ROS sensor_msgs/Image using Face Recognition and outputs detected faces with labels as ROS opencv_apps/FaceArrayStamped message. See Tutorials for more info.

4.2.1 Subscribed Topics

`image` (sensor_msgs/Image)
The image topic. Should be remapped to the name of the real image topic.

`faces` (opencv_apps/FaceArrayStamped)
Array of detected face location in image coordiinates.

4.2.2 Published Topics

`~output` (opencv_apps/FaceArrayStamped)
A copy of input image which indicates detected faces position as a circle

`~debug_image` (sensor_msgs/Image)
A copy of input image which indicates detected faces' positions, labels and confidences

4.2.3 Parameters

`~approximate_sync` (`bool`, default: false)
Approximately synchronize messages of input image and face array

`~queue_size` (`int`, default: 100)
Size of queue for subscribing topics

`~model_method` (`string`, default: "eigen")
Method for face recognition (Either "eigen", "fisher" or "LBPH")

`~use_saved_data` (`bool`, default: true)
Load and train data from path specified by ~data_dir

`~save_train_data` (`bool`, default: true)
Save train data to path specified by ~data_dir for retraining

`~data_dir` (`string`, default: "~/.ros/opencv_apps/face_data")
Path to directory for saving train data

`~face_model_width` (`int`, default: 190)
Width of training face image

`~face_model_height` (`int`, default: 90)
Height of training face image

`~face_padding` (`double`, default: 0.1)
Padding ratio for each face

`~model_num_components` (`int`, default: 0)
Number of components for face recognizer model (0 is treated as unlimited)

`~model_threshold` (`double`, default: 8000.0)
Threshold for face recognizer model

Example 1: camera

- Installing packages
  - apt-get / system-wide
  - From source
- Live demo

Example 2: sublisher

- A bit of networking
- Talking to an Arduino (rosserial_python)
- Moveit (MoveGroup)
- Combined publisher/subscriber
  - Alternate version
- Live demo

```python
import rospy
import std_msgs.msg

class BallGripper:

    def __init__(self):
        rospy.init_node('ball_gripper', anonymous=True)

        self.command_listener = rospy.Subscriber('/ball_gripper/command', std_msgs.msg.String, self.callback)
        self.servo_publisher = rospy.Publisher('/servo', std_msgs.msg.UInt16, queue_size=10)

    def callback(self, msg):
        rospy.loginfo(rospy.get_caller_id() + 'I heard %s', msg.data)
        if msg.data == "release":
            release_msg = std_msgs.msg.UInt16(180)
            self.servo_publisher.publish(release_msg)


if __name__ == '__main__':
    ball_gripper = BallGripper()
    rospy.spin()
```

Offline question 1

- What are some other kinematic models that are commons in robotics? Is it common to have to derive kinematic model for every new robotic system/component, or they usually share similar kinematic model for each module that can be easily reused?

  - Unicycle model is part of a family of models often used for wheeled robots (bicycle model, Dubin car etc.).
  - Stanford teaches an entire class on this: ME 227
  - For most complicated robot, people rely on urdf's and dedicated packages that compute dynamics from them
    - Bullet, Drake, MuJoCo, Matlab Simscape, RigidBodyDynamics.jl …

master **bullet3** / examples / pybullet / gym / **pybullet_data** / Go to file Add file

erwincoumans Merge branch 'master' of github.com:erwincoumans/bullet3 caf6718 13 days ago **History**

..		
a1	update a1 urdf to match naming for our software	13 days ago
args	enable intermediate log for walk, so you can restart if stuck in loca...	10 months ago
bicycle	add bicycle resources and testBike.py script (use python -m pybullet_...	3 years ago
biped	PyBullet: added preliminary DART and MuJoCo backend files, MuJoCo can...	2 years ago
data	DeepMimic: add retrained walk motion with COM	2 months ago
differential	pybullet a bit more refactoring, moving around files.	3 years ago
domino	PyBullet: add domino asset and example	2 years ago
franka_panda	add friction anchors for Panda gripper (prevents/reduces sliding obje...	8 months ago
gripper	add more URDF files to pybullet_data	3 years ago
heightmaps	export btHeightfieldTerrainShape to PyBullet. Note that tinyrenderer ...	14 months ago
humanoid	allow pybullet_envs.deep_mimic.testrl --arg_file run_humanoid3d_backf...	2 years ago
husky	add more URDF files to pybullet_data	3 years ago
jenga	add more URDF files to pybullet_data	3 years ago
kiva_shelf	fix sdf warning	3 years ago
kuka_iiwa	pybullet a bit more refactoring, moving around files.	3 years ago
laikago	laikago_toes_zup.urdf: fill in inertia values, computed as PyBullet d...	last month
lego	add more URDF files to pybullet_data	3 years ago
mini_cheetah	tweak Mini Cheetah URDF/MTL	15 months ago
mjcf	pybullet a bit more refactoring, moving around files.	3 years ago
policies	Fix for 1643, allow to instantiate multiple PyBullet Gym environments...	2 years ago
quadruped	add test script for spirit40	14 days ago
racecar	pybullet a bit more refactoring, moving around files.	3 years ago
random_urdfs	enable pdControlPlugin by default (requires pdControlPlugin.cpp and b...	2 years ago
roboschool/models_outdoor/stadium	pybullet a bit more refactoring, moving around files.	3 years ago
table	pybullet a bit more refactoring, moving around files.	3 years ago
table_square	add more URDF files to pybullet_data	3 years ago
tray	pybullet a bit more refactoring, moving around files.	3 years ago

Offline question 2

- In slide 31, we briefly went through a catkin_create_pkg command to build ROS package. Do dependencies always have to be pass via command-line? Or if there's a way for us to specify dependencies via the XML or a config file?

  - catkin_create_pkg is just a helper function to get you started
  - The xml files in the package can be edited to add dependencies (package.xml in this case)
  - rosdep is another tool that lets you deal with system dependencies

Other questions?