ROS SLAM

WeGo & WeCAR

WeGo

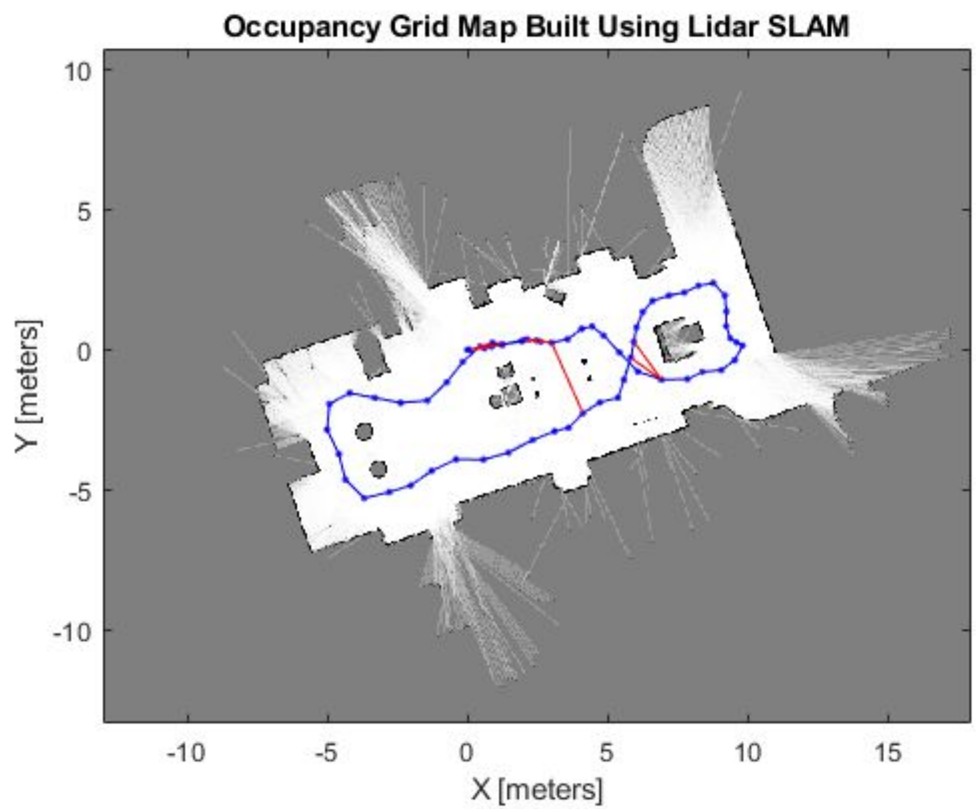
목 차

01

SLAM Introduction

01 SLAM Introduction

- SLAM은 Simultaneous Localization And Mapping의 줄임말
- 한글로 동시적 위치 추정 및 지도 작성이다.
- 간단하게, 새롭게 무인도를 탐험하면서 지도를 생성하는 것 == SLAM



01 SLAM Introduction

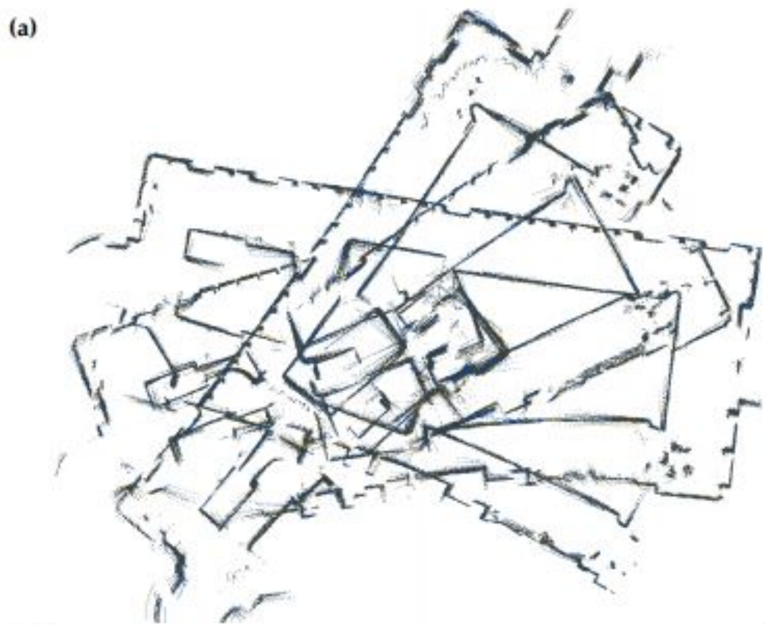
- SLAM의 문제
- 지도를 실제와 유사하게 만든다고 한다면 연속된 공간에서 무한히 많은 차원으로 존재할 수 있으므로 지도 생성이 굉장히 어려워진다.
- Grid Map과 같은 형태를 사용할 때도 수 많은 변수로 설명이 가능하며, 이를 통해 위치에 대한 확률을 계산하는 것이 매우 어렵다.
- 지도가 존재할 때 Localization만을 수행하는 것은 어렵지 않으며, Localization이 성공할 수 있을 때 지도를 생성하는 것도 어렵지 않지만, 이 둘을 동시에 해결하기는 어렵다. → Chicken & Egg Problem

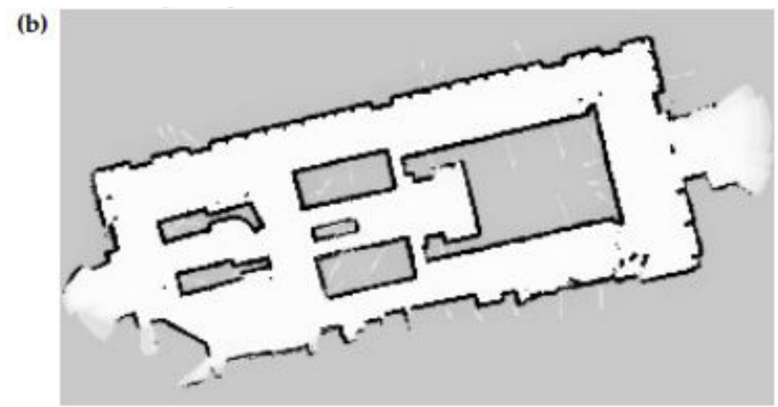
01 SLAM Introduction

- SLAM의 문제의 난이도를 결정하는 요소들
- 생성하려는 지도의 크기
- 당연하겠지만 주변 환경 센싱 및 자기 위치 추정을 위한 센서의 노이즈
- 주변 환경의 반복성 및 인식 모호성 → 복도, 숲 등에서 쉽지 않음

01 SLAM Introduction

- 실내 이동 데이터를 오도메트리 정보를 이용하여 Mapping한 결과 (a)
- (a)의 결과를 이용하여 Mapping 알고리즘을통해서 처리한 결과 (b)



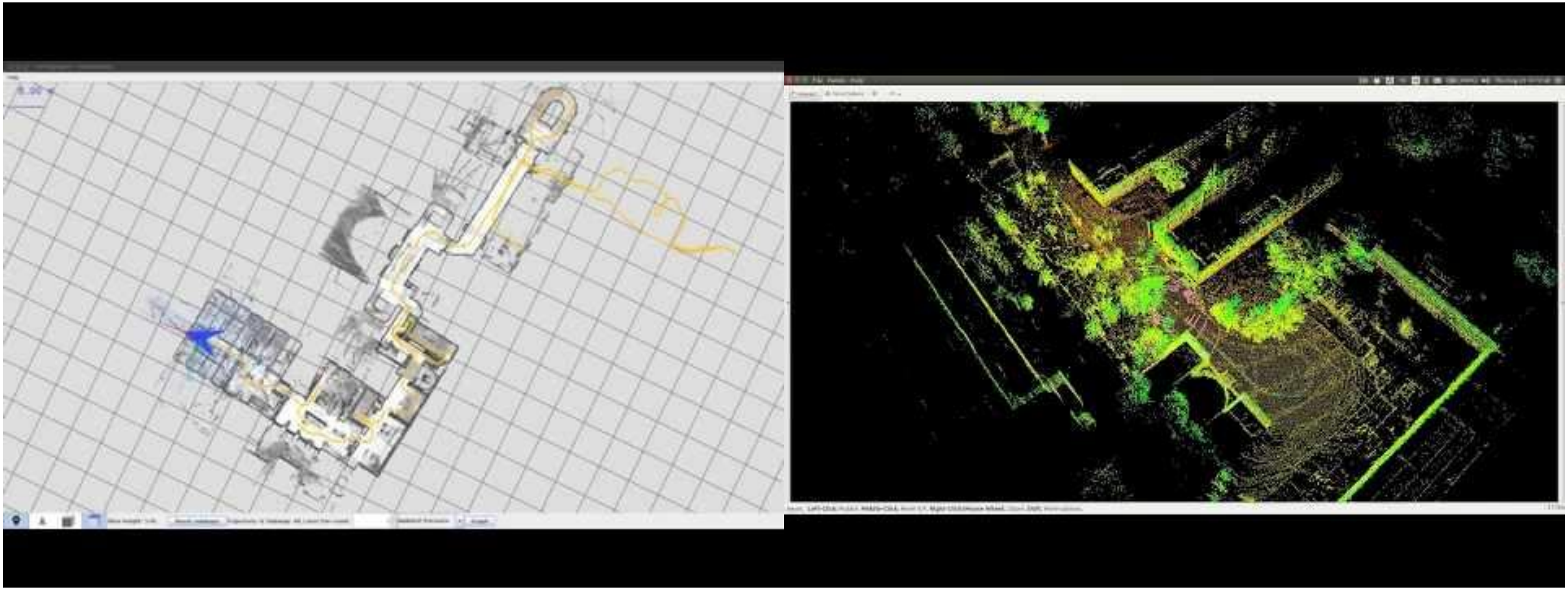


01 SLAM Introduction

- SLAM을 위한 대표적인 센서는 Camera, Lidar
- 두 센서는 특성이 다르며, 사용하는 방식 또한 매우 다르다.

01 SLAM Introduction

- Lidar SLAM
- http://www.youtube.com/watch?v=DM0dpHLhtX0
- http://www.youtube.com/watch?v=7uCxLUs9fwQ



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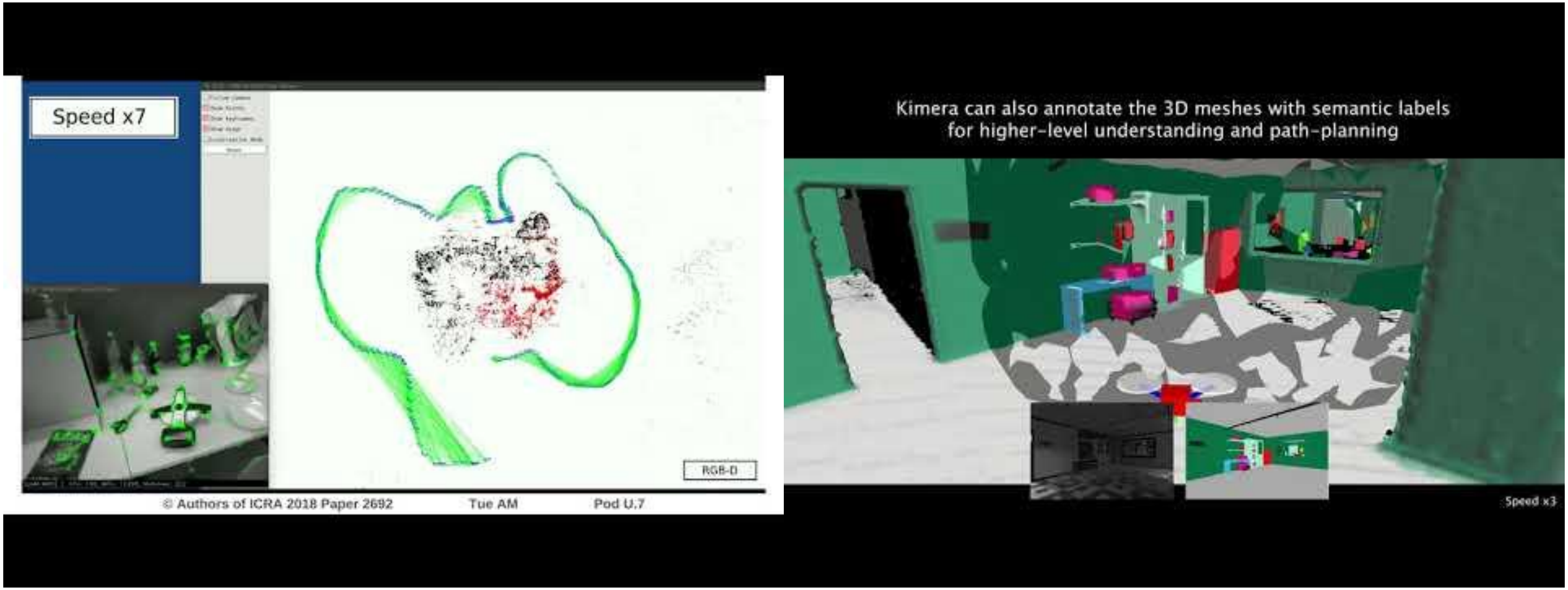
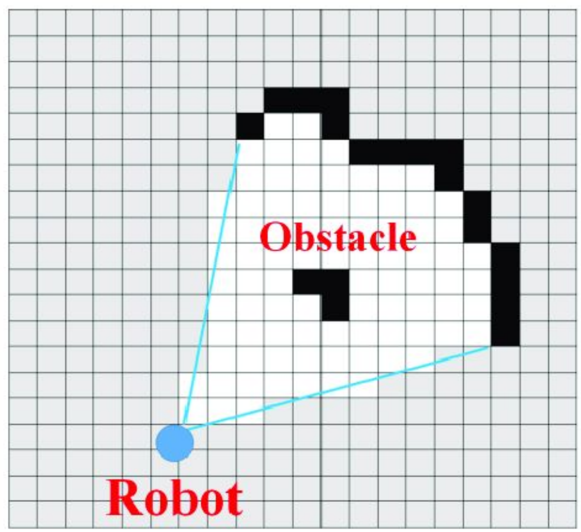
01 SLAM Introduction

- **Visual SLAM**
- http://www.youtube.com/watch?v=IuBGKxgaxS0
- http://www.youtube.com/watch?v=-5XxXRABXJs



- Grid Map
  - 공간을 Cell로 나누어서 표현하며, 이 공간 구조는 고정되어 있음
  - 각 Cell은 Occupied Space와 Free Space로 구분된다.
  - Non-Parametric Model - 파라미터의 개수가 정해져있지 않음
  - Feature map이 아닌 전체 센서 데이터를 모두 저장하는 방식
  - 위의 이유로 인해 상당히 많은 Memory를 사용
  - Feature map이 아니므로 Feature Detector에 의존 하지 않음



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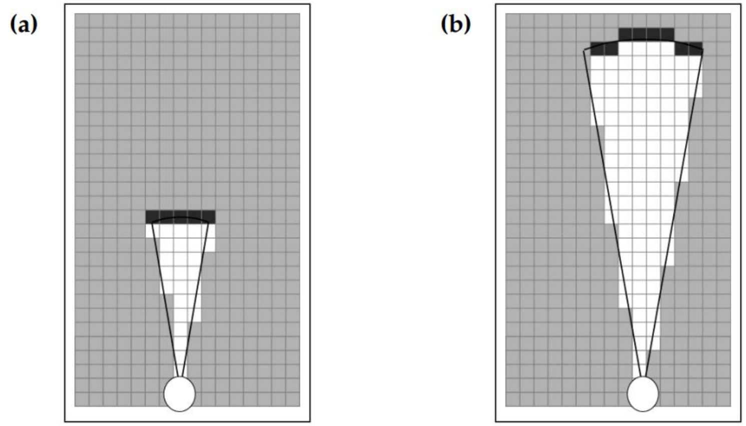
- Occupancy Grid Mapping
  - 로봇의 t = 0 ~ T 까지의 모든 포즈(x)와 모든 측정값(z)가 주어져있을 때, 이를 기반으로 아래의 식을 계산하는 방식

$$p(m|z_{1:t}, x_{1:t})$$

  - t = 0 ~ T까지의 제어값(u)는 모두 포즈(x)에 포함되어 있기 때문에 사용하지 않는다.
  - 지도를 Grid Map을 이용하므로, 지도는 각 셀의 집합으로 되어있다.
  - 이를 이용하여 Grid Cell을 하나씩 채워나가는 과정



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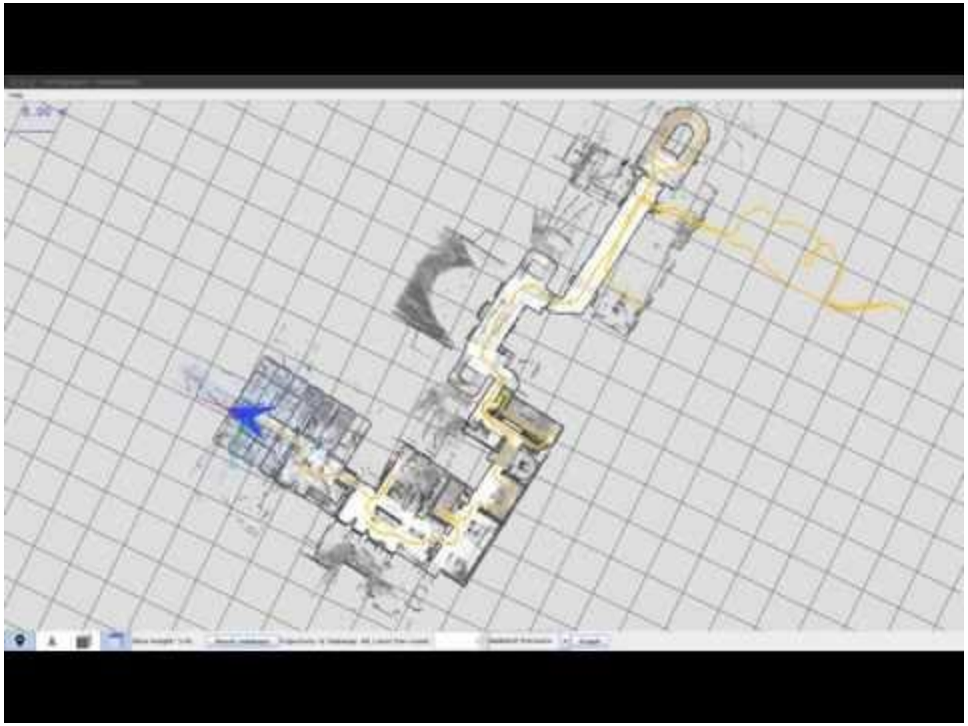
01 SLAM Introduction

- SLAM
  - SLAM은 Occupancy Grid Mapping과 Localization을 동시에 진행
  - 초기 위치를 특정 값([0, 0]과 같은 값)으로 정하고, 센서 데이터, 제어 데이터, 현재 위치 등의 데이터를 활용하여 지도 생성 및 위치 추정을 동시에 진행
  - http://www.youtube.com/watch?v=DM0dpHLhtX0



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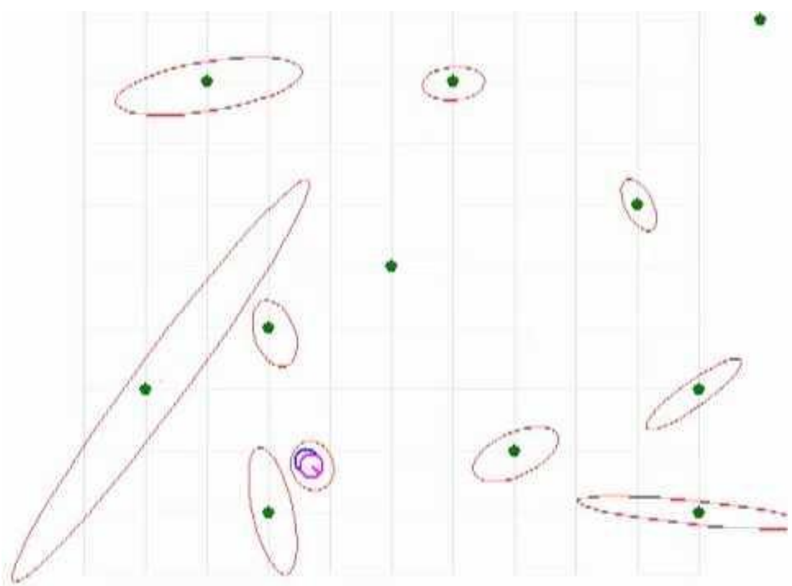
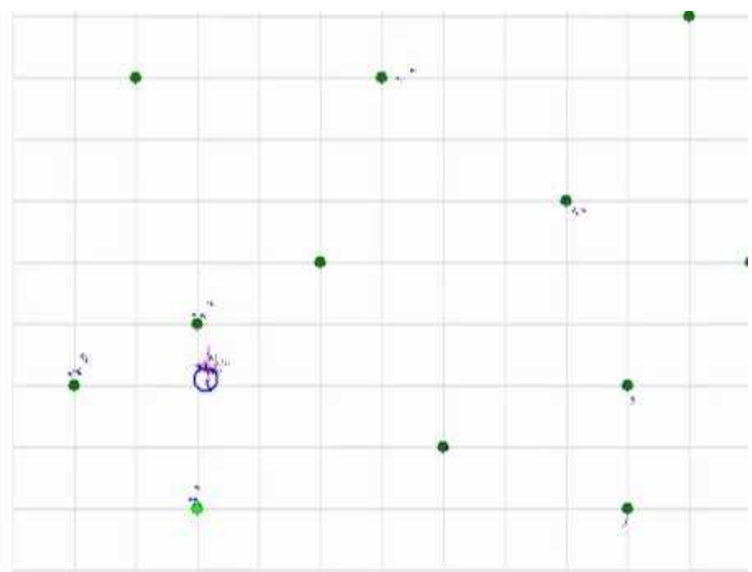
- SLAM
- 1990 ~ 2000 - Extended Kalman Filter 기반의 SLAM(pose-ekf-slam)
- 2000 ~ 2007 - Particle Filter 기반의 SLAM (GMapping)
- 2007 ~ 현재 - Maximum A Posteriori Estimation 기반의 SLAM (Cartographer)
- http://www.youtube.com/watch?v=vCVS9WAffi4
- http://www.youtube.com/watch?v=-hXEYhOO_XA





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02 SLAM Package

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02 SLAM Package

- Gmapping
  - laser-based SLAM, create a 2-D occupancy grid map and pose data
- Published Topics
  - /map_metadata (nav_msgs/MapMetaData) - Map Meta Data Type Map
  - /map (nav_msgs/OccupancyGrid) - OccupancyGrid Map Data
  - ~entropy (std_msgs/Float64) - Entropy of the distribution over the robot's pose
- Subscribed Topics
  - /scan (sensor_msgs/LaserScan) - Lidar LaserScan Data
  - tf (tf/tfMessage) - Transform necessary to relate frames for laser, base, and odometry

02 SLAM Package

- Parameters(Default)
  - ~throttle_scans(1) – Process 1 out of every this many scans (set it to higher number to skip more)
  - ~base_frame(base_link) – The frame attached to the mobile base.
  - ~map_frame (map) – The frame attached to the map
  - ~odom_frame (odom) – The frame attached to the odometry system
  - ~map_update_interval (5.0) – How long between updates to the map. Lowering this number updates the occupancy grid more often, at the expense of greater computational load.
  - ~maxUrange (80.0) – The maximum usable range of the laser. A beam is cropped to this value.
  - ~sigma (0.05) – The sigma used by the greedy endpoint matching
  - ~kernelSize (1) – The kernel in which to look for a correspondence
  - ~lstep (0.05) – The optimization step in translation
  - ~astep (0.05) – The optimization step in rotation
  - ~iterations (5) – The number of iterations of the scanmatcher
  - ~lsigma (0.075) – The sigma of a beam used for likelihood computation
  - ~ogain (3.0) – Gain to be used while evaluating the likelihood, for smoothing the resampling effects
  - ~lskip (0) – Number of beams to skip in each scan. Take only every (n+1)th laser ray for computing
  - ~minimumScore (0.0) – Minimum score for considering the outcome of the scan matching good. Can avoid jumping pose estimates in large open spaces when using laser scanners with limited range.

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- Parameters(Default)
  - ~srr (0.1) – Odometry error in translation as a function of translation (rho/rho)
  - ~srt (0.2) – Odometry error in translation as a function of rotation (rho/theta)
  - ~str (0.1) – Odometry error in rotation as a function of translation (theta/rho)
  - ~stt (0.2) – Odometry error in rotation as a function of rotation (theta/theta)
  - ~linearUpdate (1.0) – Process a scan each time the robot translates this far
  - ~angularUpdate (0.5) – Process a scan each time the robot rotates this far
  - ~temporalUpdate (-1.0) – Process a scan if the last scan processed is older than update time in seconds. A value less than zero will turn time based updates off.
  - ~resampleThreshold (0.5) – The Nelf based resampling threshold
  - ~particles (30) – Number of particles in the filter
  - ~xmin (-100.0) – initial map size (in meters)
  - ~ymin (-100.0) – initial map size (in meters)
  - ~xmax (100.0) – initial map size (in meters)
  - ~ymax (100.0) – initial map size (in meters)
  - ~delta (0.05) – Resolution of the map (in meters per occupancy grid block)

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02 SLAM Package

- Parameters(Default)
  - ~llsamplerange (0.01) - Translational sampling range for the likelihood
  - ~llsamplestep (0.01) - Translational sampling step for the likelihood
  - ~lasamplerange (0.005) - Angular sampling range for the likelihood
  - ~lasamplestep (0.005) - Angular sampling step for the likelihood
  - ~transform_publish_period (0.05) - How long (in seconds) between transform publication.
  - ~occ_thresh (0.25) – Threshold on gmapping's occupancy values. Cells with greater occupancy are considered occupied
  - ~maxRange - The maximum range of the sensor. If regions with no obstacles within the range of the sensor should appear as free space in the map, set maxUrange < maximum range of the real sensor <= maxRange

- http://wiki.ros.org/gmapping

- $ rosrun gmapping slam_gmapping

02 SLAM Package

- Hector mapping
  - Lidar Only SLAM using LaserScan Data
- Published Topics
  - /map_metadata (nav_msgs/MapMetaData) - Map Meta Data Type Map
  - /map (nav_msgs/OccupancyGrid) - OccupancyGrid Map Data
  - /slam_out_pose (geometry_msgs/PoseStamped) - Estimated Robot Pose without Covariance
  - /poseupdate (geometry_msgs/PoseWithCovarianceStamped) - Estimated Robot Pose with Gaussian Covariance
- Subscribed Topics
  - /scan (sensor_msgs/LaserScan) - Lidar LaserScan Data
  - /syscommand (std_msgs/String) - When Publish Message "reset", Map and Robot Pose are reset

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- Parameters(Default)
  - ~base_frame (base_link) - The name of the base frame of the robot
  - ~map_frame (map_link) - The name of map frame
  - ~odom_frame (odom) - The name of odom frame
  - ~map_resolution (0.025) - The map resolution (meter), the length of one cell
  - ~map_size (1024) - The Size of Map (1024 * 1024 Cells)
  - ~map_start_x (0.5) - Location of the Origin of Map X(0.0 ~ 1.0)
  - ~map_start_y (0.5) - Location of the Origin of Map Y(0.0 ~ 1.0)
  - ~map_update_distance_thresh (0.4) - Threshold for performing map updates (meter)
  - ~map_update_angle_thresh (0.9) - Threshold for performing map updates (radian)
  - ~map_pub_period (2.0) - The map publish period (second)
  - ~map_multi_res_levels (3) - The number of map multi-resolution grid levels

- Parameters(Default)
  - ~update_factor_free (0.4) - updates of free cells in the range [0.0, 1.0]. A value of 0.5 means no change.
  - ~update_factor_occupied (0.9) - updates of occupied cells in the range [0.0, 1.0]. A value of 0.5 means no change.
  - ~laser_min_dist (0.4) - The minimum distance [m] for laser scan endpoints to be used by the system.
  - ~laser_max_dist (30.0) - The maximum distance [m] for laser scan endpoints to be used by the system.
  - ~laser_z_min_value (-1.0) - The minimum height [m] relative to the laser scanner frame for laser scan endpoints to be used by the system. Scan endpoints lower than this value are ignored.
  - ~laser_z_max_value (1.0) - The maximum height [m] relative to the laser scanner frame for laser scan endpoints to be used by the system. Scan endpoints higher than this value are ignored.
  - ~pub_map_odom_transform (true) - Determine if the map->odom transform should be published by the system.
  - ~output_timing (false) - Output timing information for processing of every laser scan via ROS_INFO.

02 SLAM Package

- Parameters(Default)
  - ~scan_subscriber_queue_size (5) - The queue size of the scan subscriber. This should be set to high values (for example 50) if log-files are played back to hector_mapping at faster than realtime speeds.
  - ~pub_map_scanmatch_transform (true) - Determines if the scanmatcher to map transform should be published to tf. The frame name is determined by the 'tf_map_scanmatch_transform_frame_name' parameter.
  - ~tf_map_scanmatch_transform_frame_name (scanmatcher_frame) - The frame name when publishing the scanmatcher to map transform as described in the preceding parameter.

- http://wiki.ros.org/hector_mapping

- $ roslaunch hector_slam_launch tutorial.launch

03 SLAM Demo

- Gmapping
  - EKF, Particle Filter, Maximum A Posteriori Estimation방법 중 Particle Filter를 기반으로 한 SLAM알고리즘
  - Input - 플랫폼의 움직임에 해당하는 정보인 Odometry, 2D LiDAR의 거리 데이터
  - Odometry 정보를 사용하므로, 위치가 과도하게 튀는 현상은 없음
  - Odometry 정보에 대한 의존도가 높으므로, Odometry 데이터가 오차가 심할 경우, 제대로 Mapping이 되지 않거나, Mapping 중간에 지도가 틀어질 수 있음
  - Odometry에 오차가 있을 경우에도 주변 환경이 특징이 많아, Map - Sensor Data 사이의 Matching이 잘 되는 경우에 우수하게 동작함

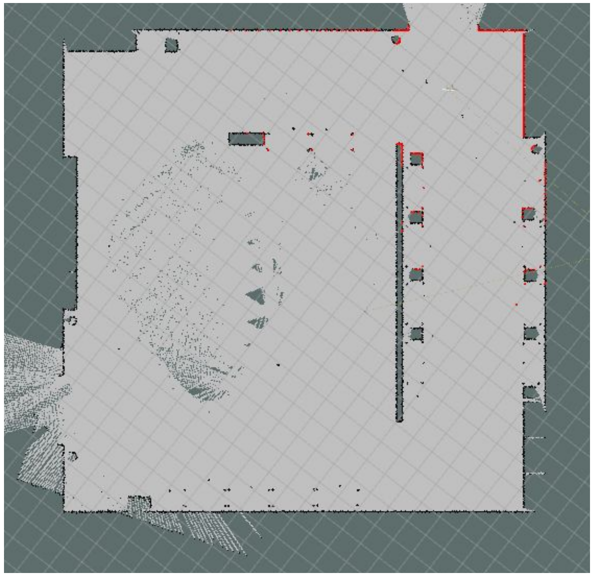
03 SLAM Demo

- Gmapping
- Gmapping ROS Wiki - http://wiki.ros.org/gmapping
- Gmapping Github - https://github.com/ros-perception/slam_gmapping

- Related Papers
  - Improving Grid-based SLAM with Rao-Blackwellized Particle Filters by Adaptive Proposals and Selective Resampling - http://www.informatik.uni-freiburg.de/~stachnis/pdf/grisetti05icra.pdf
  - Improved Techniques for Grid Mapping with Rao - Blackwellized Particle Filters - http://www.informatik.uni-freiburg.de/~stachnis/pdf/grisetti07tro.pdf

03 SLAM Demo

- Gmapping
  - $ roslaunch wecar teleop.launch
  - $ roslaunch wecar gmapping_wecar.launch
  - 지도 작성이 종료된 후
  - $ roscd wecar/map
  - $ rosrun map_server map_saver -f "FILENAME"
  - 위 명령어로 지도 저장 가능



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03 SLAM Demo

- hector mapping - Lidar Only SLAM using LaserScan Data
  - EKF, Particle Filter, Maximum A Posteriori Estimation방법 중 Maximum A Posteriori Estimation을 기반으로 한 SLAM알고리즘이지만, 최근에 G2O 등의 라이브러리를 사용하는 방식과는 차이가 있는 최적화 방법을 사용
  - Input - 2D LiDAR의 거리 데이터
  - Hector SLAM 알고리즘은 LiDAR의 정보만을 사용하여, Mapping 및 Localization이 가능하며, 따라서 Hand-Held Mapping이 가능하다는 특징이 있음
  - LiDAR의 정보만을 사용하므로, Feature가 부족한 개활지 및 복도 등의 환경에서는 위치를 제대로 잡지 못하는 문제가 발생

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- hector mapping - Lidar Only SLAM using LaserScan Data
- Hector SLAM ROS Wiki - http://wiki.ros.org/hector_slam
- Hector SLAM Github -

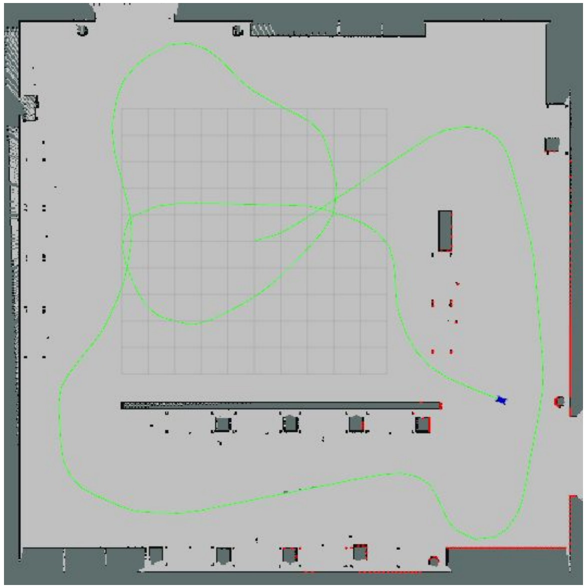
  https://github.com/tu-darmstadt-ros-pkg/hector_slam

- Related Papers
  - A Flexible and Scalable SLAM System with Full 3D Motion Estimation -

    https://ieeexplore.ieee.org/document/9336995

03 SLAM Demo

- hector mapping – Lidar Only SLAM using LaserScan Data
  - $ roslaunch wecar teleop.launch
  - $ roslaunch wecar hector_mapping_wecar.launch
  - 지도 작성이 종료된 후
  - $ roscd wecar/map
  - $ rosrun map_server map_saver -f "FILENAME"
  - 위 명령어로 지도 저장 가능



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