# Introduction:

* Robots in construction are good for many tasks, but less so for others
* A general robot that performs all tasks in the construction site seems far-off
* We would like to have a robot that verifies that work done by people/”narrow minded robots” has been done correctly – task verification.  
  We assume this robot is equipped with a camera, and a 4D-BIM model so that with YOLO-like algorithms we can verify constructed elements.  
  example: Counting the amount and checking the placement of electrical sockets in all rooms.
* Something about 4D BIM models
* Something about YOLO-like algorithms

# Related Work

Main Articles

* Monte Carlo Localization: Efficient Position Estimation for Mobile Robots
* Improved Techniques for Grid Mapping With Rao-Blackwellized Particle Filters
* Rao-Blackwellized particle filter SLAM with prior map: An experimental evaluation

If Exploration/Active:

If ChangingWorld – Discrete Factor graphs

Global Localization is a different task than tracking and is often handled via non-parametric techniques.  
< Something about how Multi-hypothesis Tracking being complicated to formulate, especially for a dynamic world>

# Preliminaries:

## Bayes Filter For a Static Binary State + Mapping with known Locations

Using bayes on the measurement model:

For the same reasoning:

Using:

We can:

Thus, we have a realized a manner with which we can update the belief over the state given a new measurement and an inverse measurement model.

To convert this filter into mapping with known locations, manipulate the variables such that:

Closed formula in Cyrill’s book  
Important to talk about the term which is the map’s prior.  
The map’s prior is required for each update step. This is a major hindrance as it may mean that even consecutive ‘occupied’ measurements may result in a belief that the cell is empty.   
<show some graphs here>  
For this reason, is usually taken to be , meaning we have no prior knowledge.

We can also talk about “Reflection Probability Mapping” as gmapping uses this technique:

From Cyrill’s book:

Text, letter

Description automatically generated

## Grid Localization – Histogram Filter

Define belief over a state:

Text, letter

Description automatically generated

## Monte Carlo Localization – Particle Filter

Define belief over a state:

Define proposal distribution – prediction over the belief

Define ratio between target distribution and proposal distribution for particle

Or in a different manner:

STUCK AND WILL CONTINUE LATER Cyrill Stachnissformulation is better in my taste

The big thing to note other than the usual, is that this algorithm requires a forward measurement model

Need to make distinct the use of particles somehow

<Talk about normalization>

<Talk about resampling>

## Fast Slam

### FastSlam2

Integral is usually approximated

## Mapping and Localization in Non-Static Environments

## Discrete factor graphs

# Methodology:

* Schedule: describing the probability of when a task is finished regardless of work rate. We don’t presume to model the process of construction. Some things take more time, but are of a significant progress to construction, and things may be built in many ways.
* Binary Sensor: provides the information of if a task is ‘finished’ or ‘not finished’.  
  It is much simpler to create such a sensor, rather than a continuous sensor that measures ‘% finished’ as each element in the construction site is different and may be built in many ways.  
  It is possible to turn the binary sensor into a more semi-continuous one by comparing against planned states of the constructed element.
* Independence: We assume independence between elements in the construction site. If there exists some dependency it can be handled via grouping and the schedule.  
  That is to say, two walls in the opposite sides of the building can be considered as the same element.
* Explorative/Active: Given the schedule and a belief over the map and location, it is possible to articulate an algorithm that will provide a plan on how to increase the ‘information gain’ in the coming actions. See chapter 7 in Cyrill book
* Note: If the schedule says that something is 100% built, than our algorithm should not alter this deduction.

## Scenario 1:

* Workers have gone home for the day
* The robot’s task is to confirm what was built during the day while performing global localization
* We have a binary sensor that measures ‘finished’/’not finished’
* We have a forward sensor model

As such:

## Scenario 2:

* Workers are in the building and at work
* The robot does reconnaissance in the building (lifelong SLAM)
* We can relax the global localization into tracking (gives rise to continuous-discrete factor graph solution?)