

BIN-PICKING DE PRECISÃO USANDO UM SENSOR 3D E UM SENSOR LASER 1D

Universidade de Aveiro
Mestrado Integrado em Engenharia Mecânica

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BIN-PICKING

- O que é?
- Porque surgiu?





ENQUADRAMENTO

Estratégia

Implementação conjugada dos sensores 3D e 1D num manipulador para realizar processos de *bin-picking indoors*.



Microsoft Kinect



Sensor Laser SICK





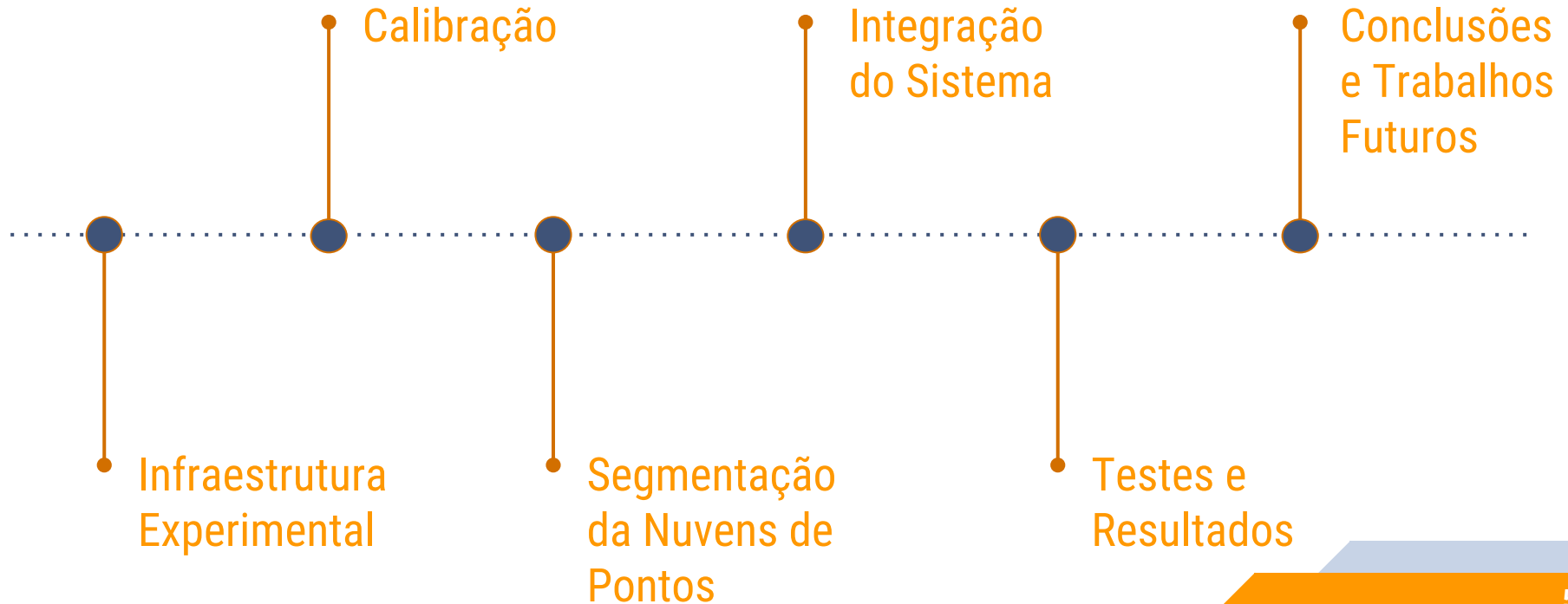
OBJETIVOS

Unidade de percepção ativa

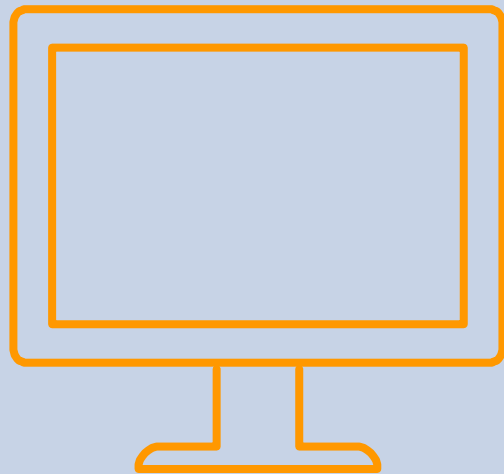
- Instalação dos sensores;
- Calibração e integração numa infraestrutura ROS;
- Solução para conjugar a informação dos sensores para agarrar objetos com elevada precisão.



ESTRUTURA DA APRESENTAÇÃO



1

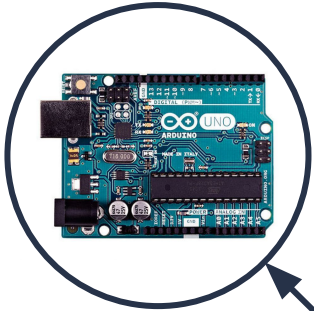


INFRAESTRUTURA EXPERIMENTAL

Hardware e Software



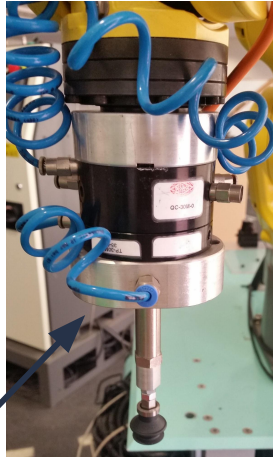
HARDWARE



Arduino UNO



Sensor Laser SICK



Robô FANUC



Microsoft Kinect



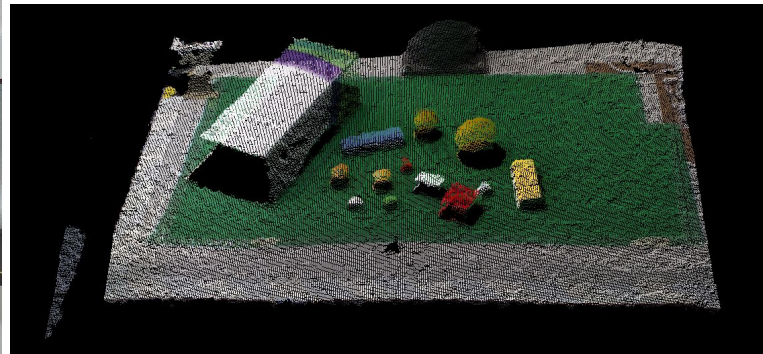
MICROSOFT KINECT

Sensor RGB-D



Contém:

- Câmera RGB;
- Emissor IR e Sensor IR - Profundidade;
- Alcance 800 mm a 4000 mm.

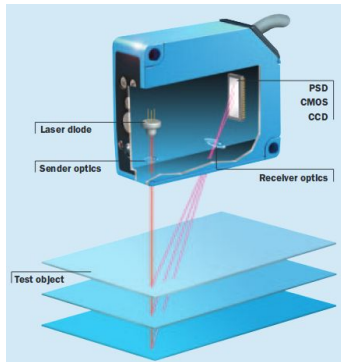




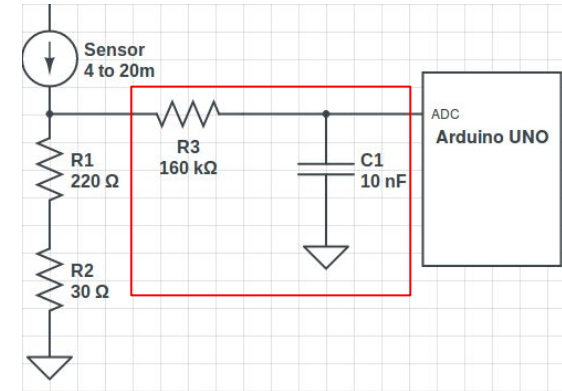
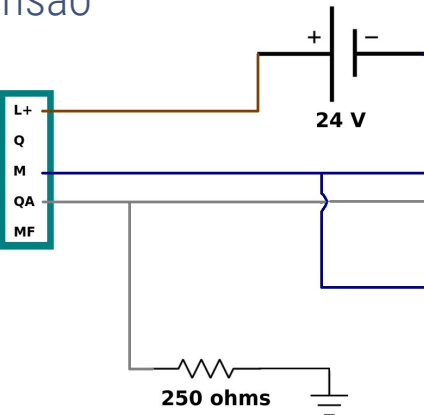
SENSOR LASER DT20 HI

Filtro passa-baixo

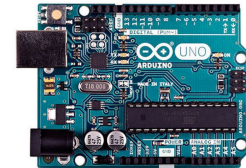
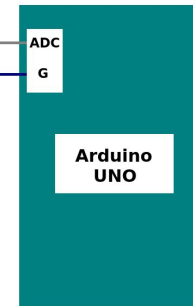
Dispositivo optoelectrónico 1D



Conversão do output
analógico de corrente para
tensão



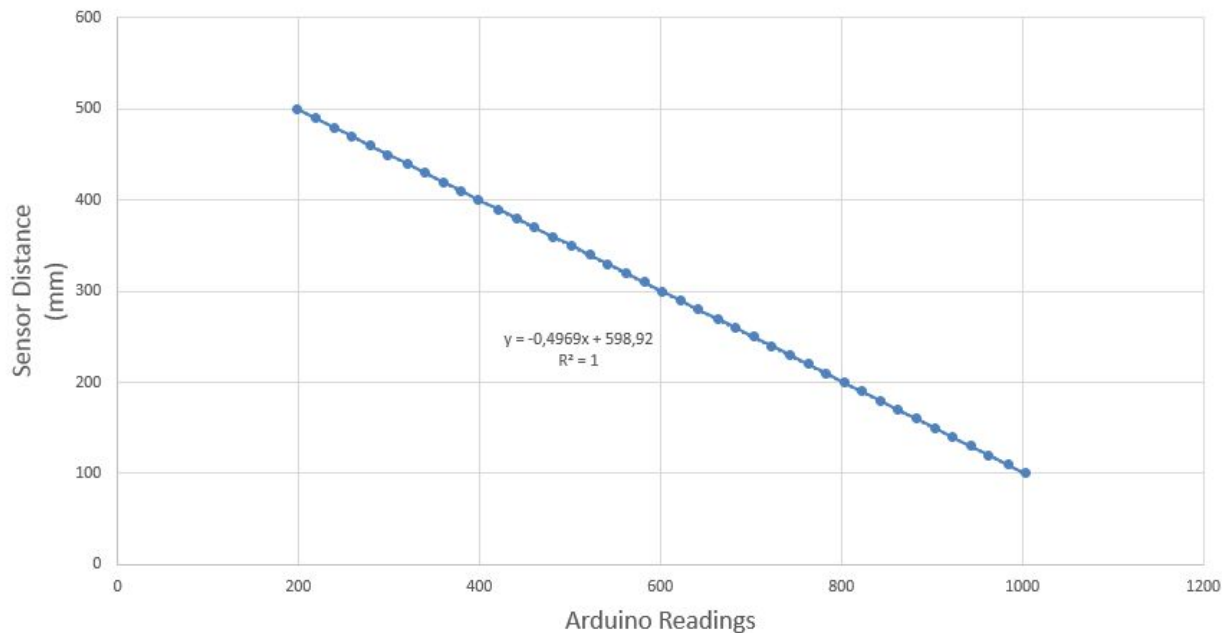
- Alcance: 100 mm - 1,000 mm;
- Resolução do Display: 1,000 μm ;
- Output Analógico : 4mA - 20mA com uma resolução de 12bits



Conversão das Leituras em Distância



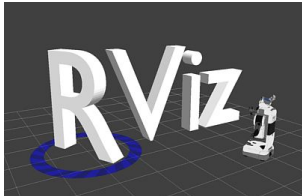
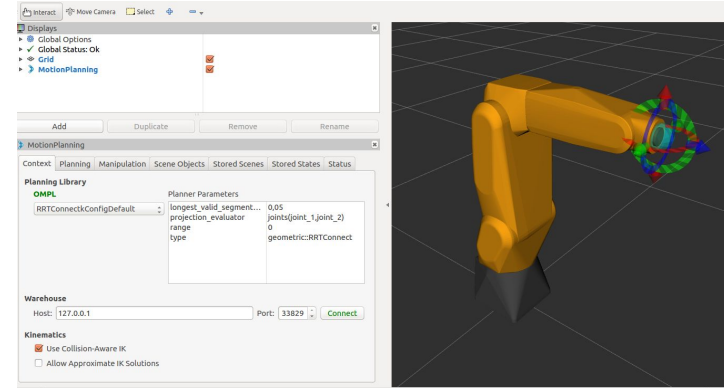
Curve to convert Arduino readings in Distance



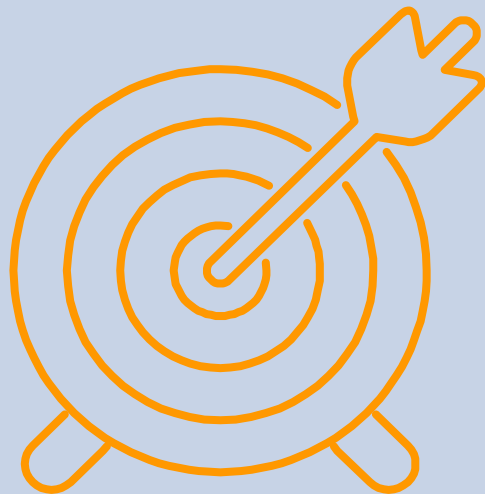
$$Distancia = -0.4969 \times Leitura + 598.92$$



SOFTWARE



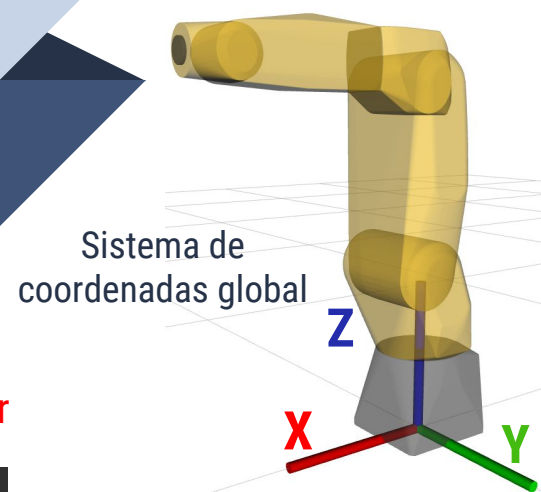
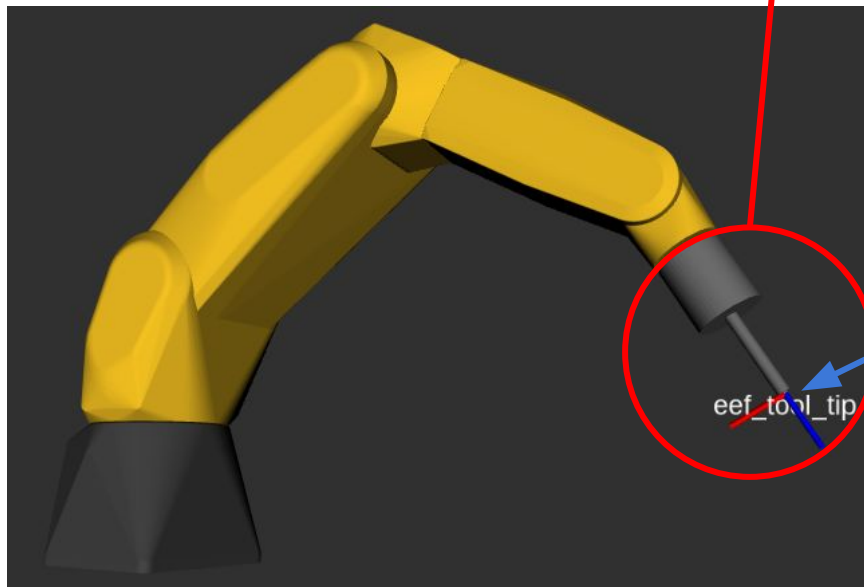
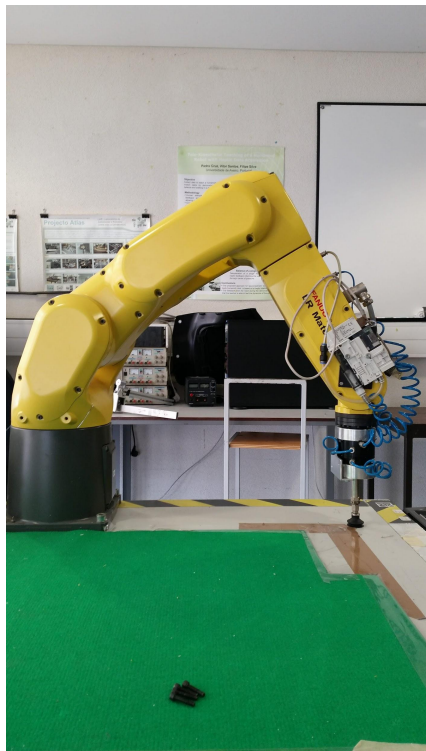
2



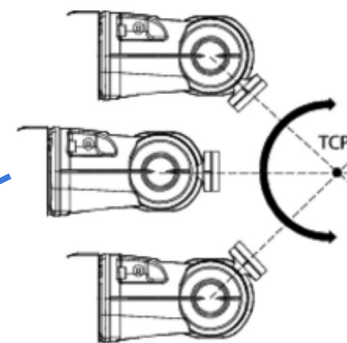
CALIBRAÇÃO



ROBÔ FANUC E END EFFECTOR



Tool Center Point





SENSOR LASER 1D

Transformação geométrica do emissor do laser à ponta do *gripper*.

- Orientação do feixe laser;
- Calibração nas diferenças do eixo X, Y e Z;



Orientação do Feixe Laser

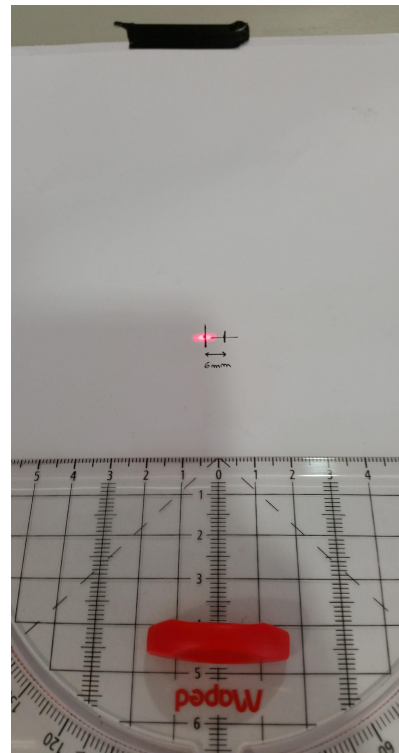
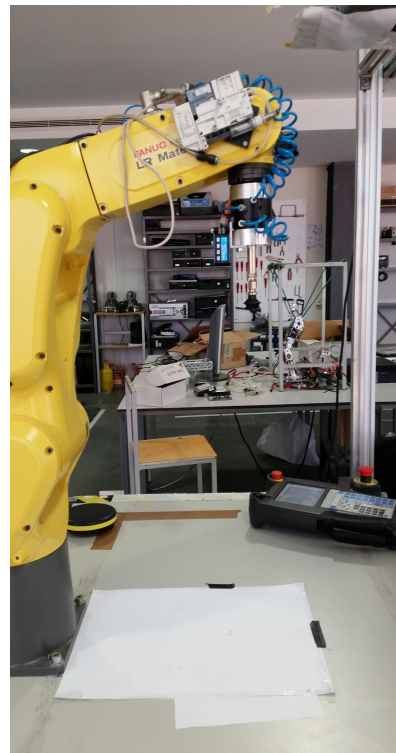
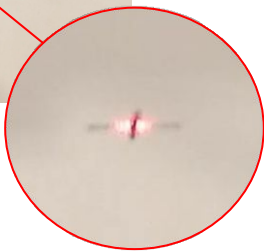
Posição Final



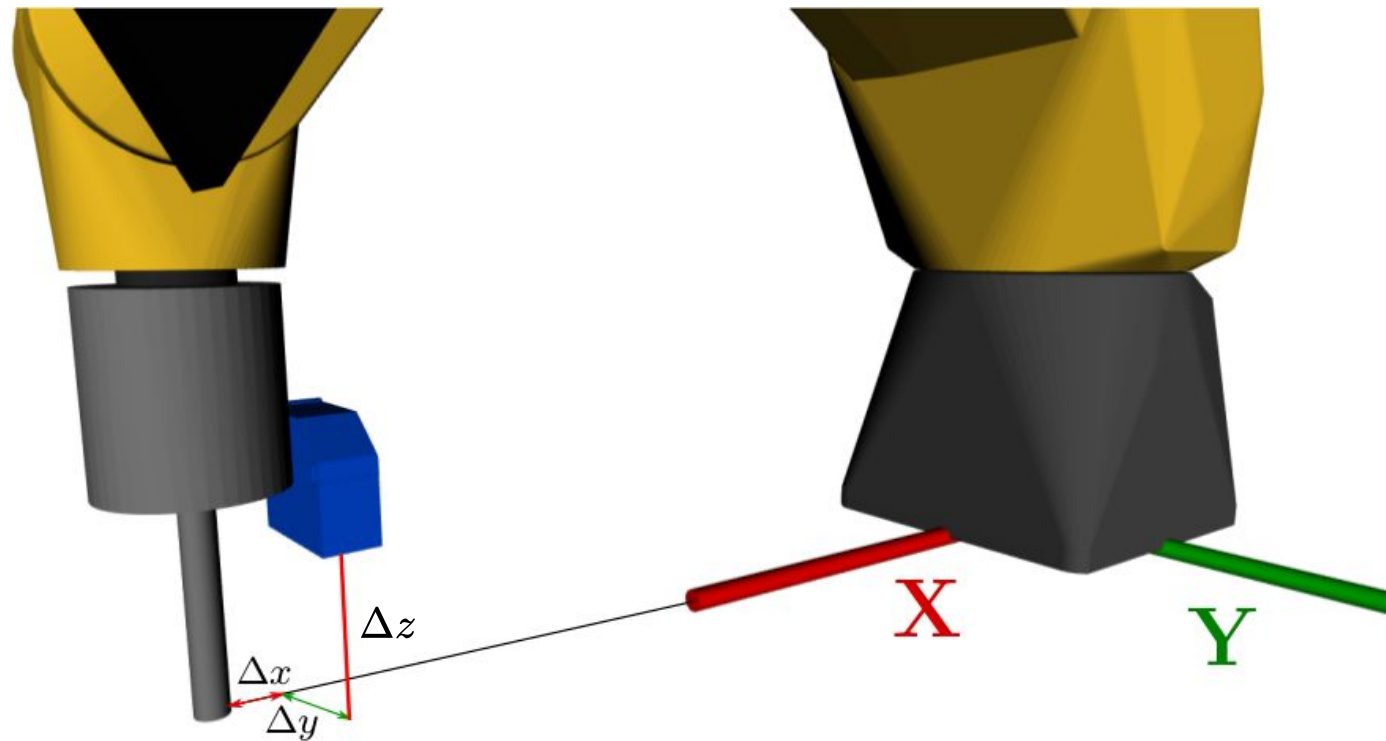
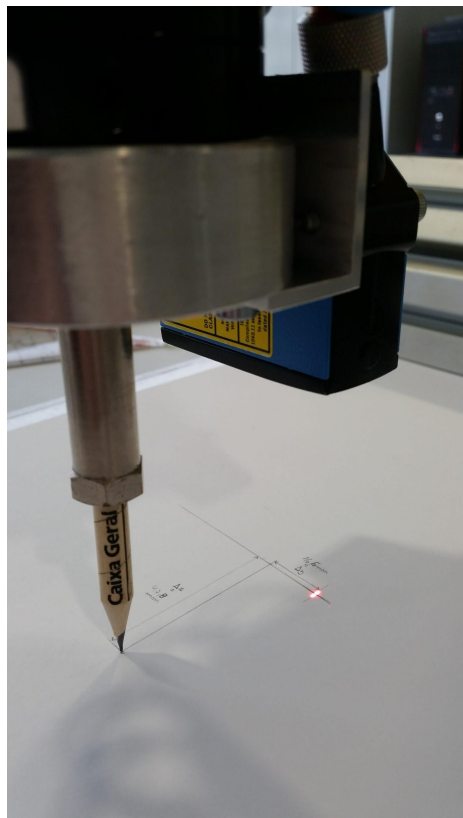
Posição Inicial



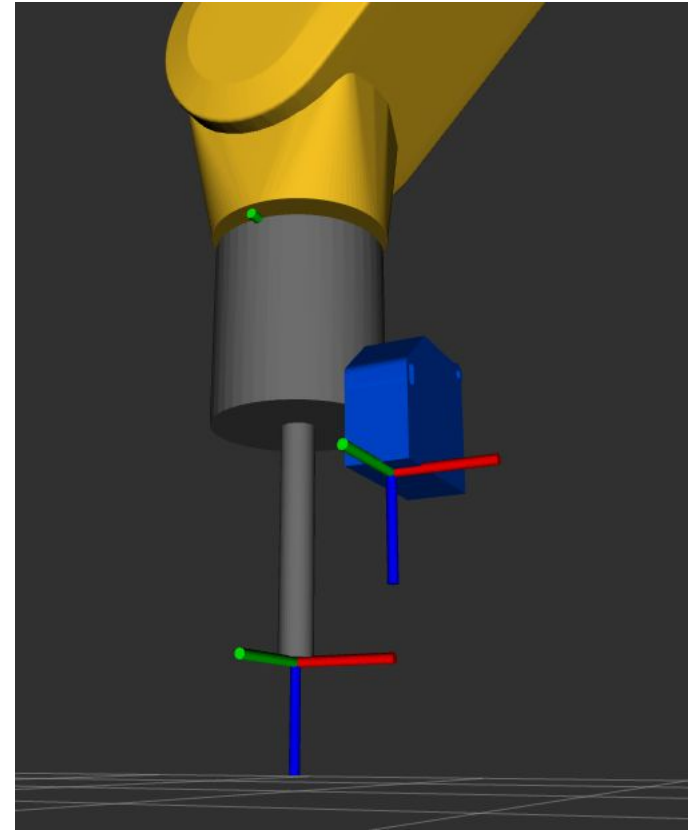
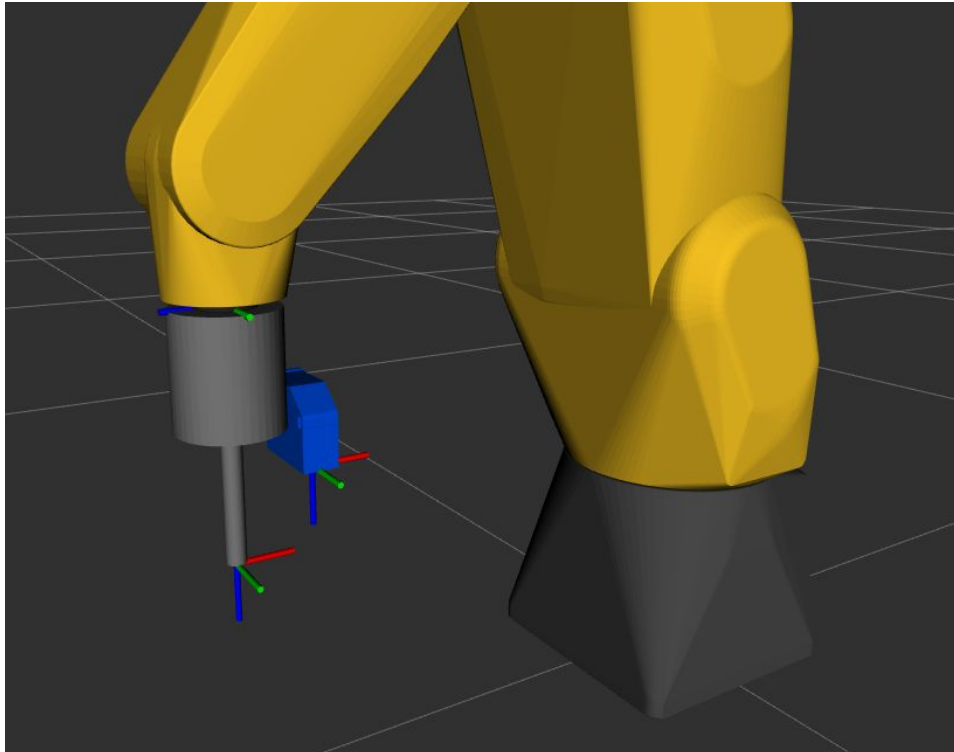
$\leq 1^\circ$

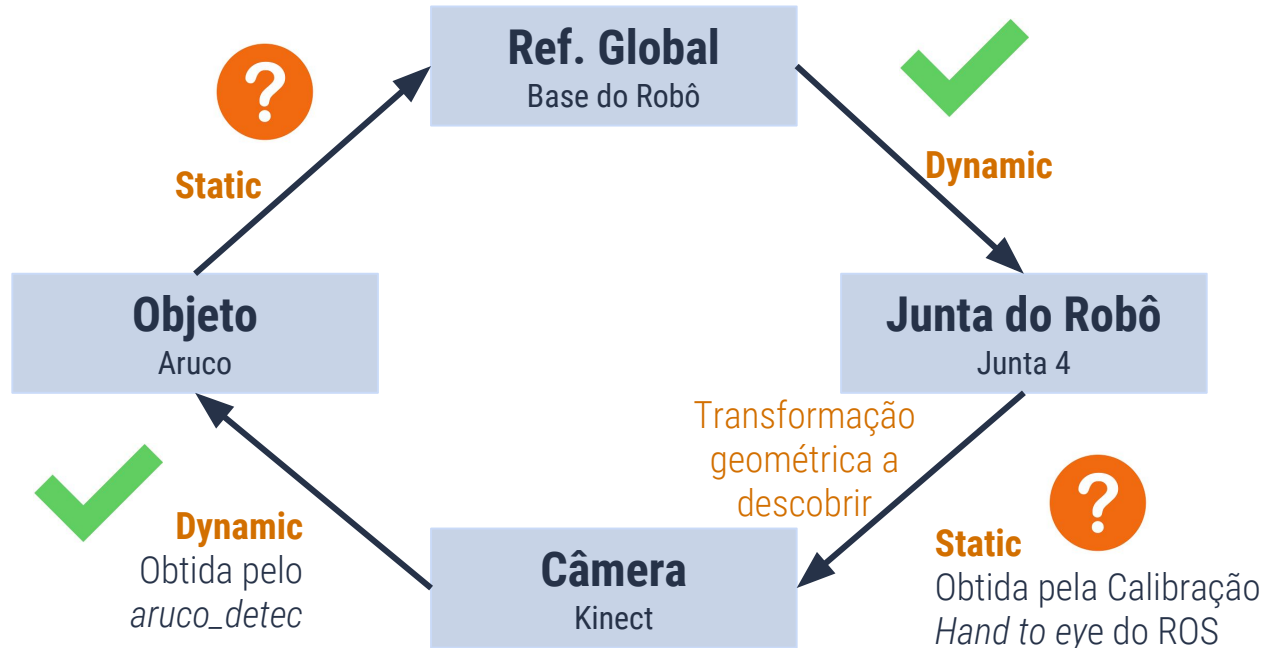


Calibração na Diferença dos Eixos X, Y e Z

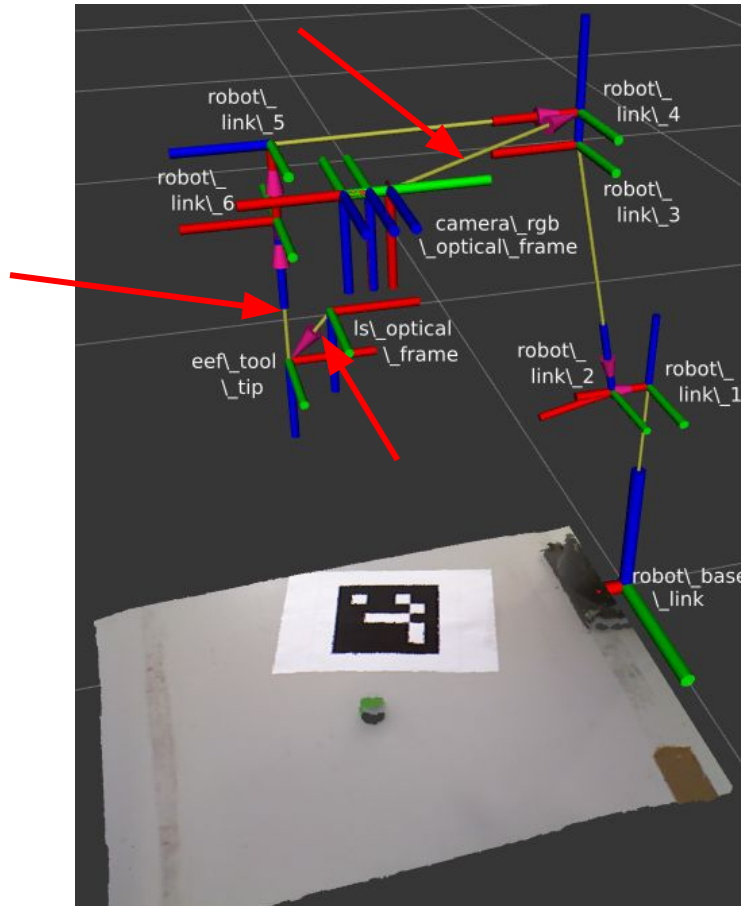
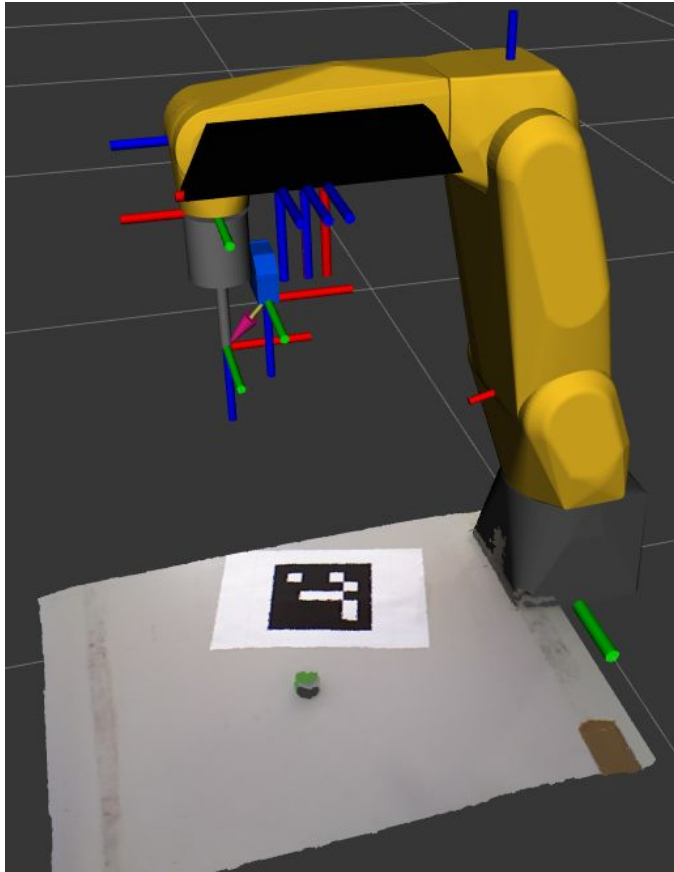


Incorporação do sistema de coordenadas do emissor do laser no sistema global





Calibração Intrínseca e Extrínseca

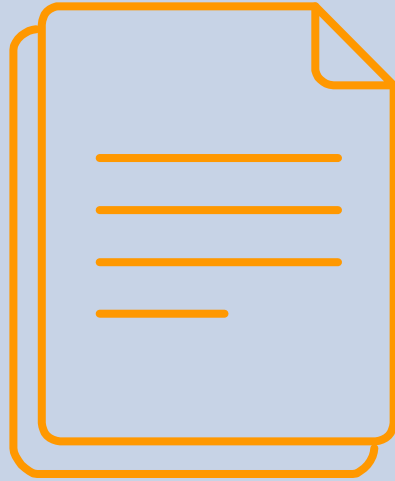


Todos os sistemas de coordenadas incorporados num sistema global

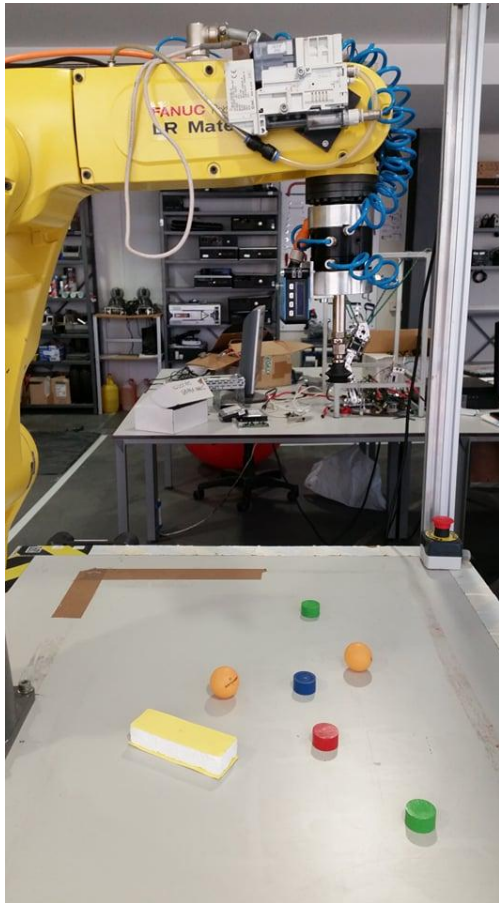
-

Base do robô

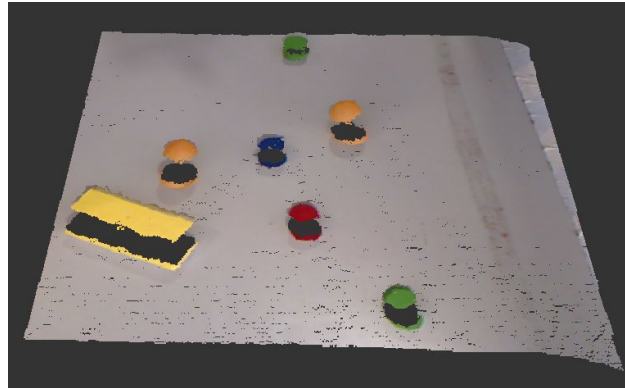
3



SEGMENTAÇÃO DA NUVEM DE PONTOS

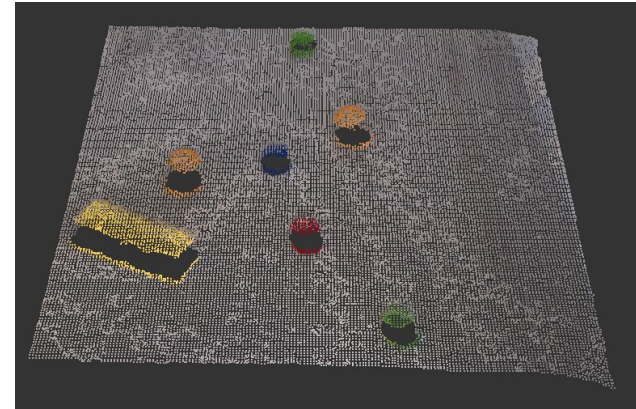


Nuvem de Pontos Inicial

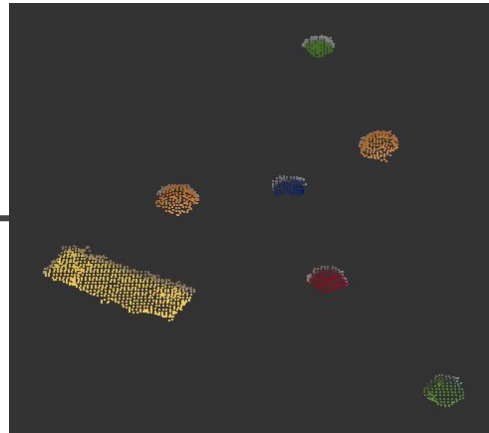


Redução do número de pontos.

Nuvem Após Filtragem



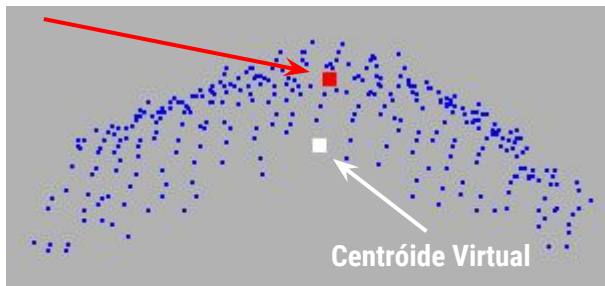
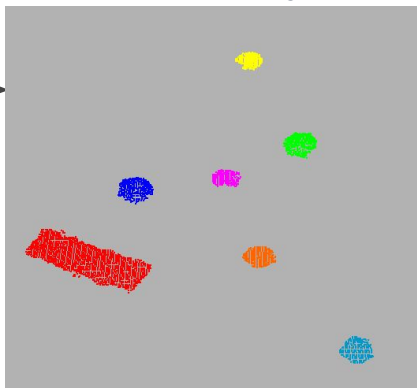
Nuvem dos Objetos Sem Background



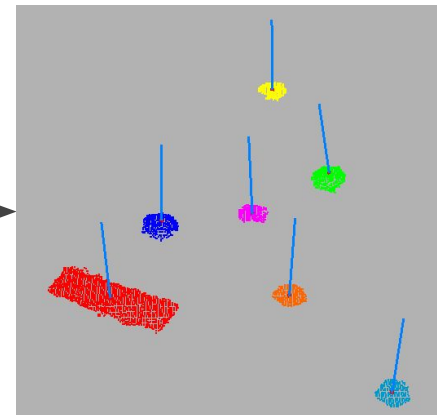
Identificação e remoção dos pontos do background .

Centróide da Superfície do Objeto

Cluster dos Objetos



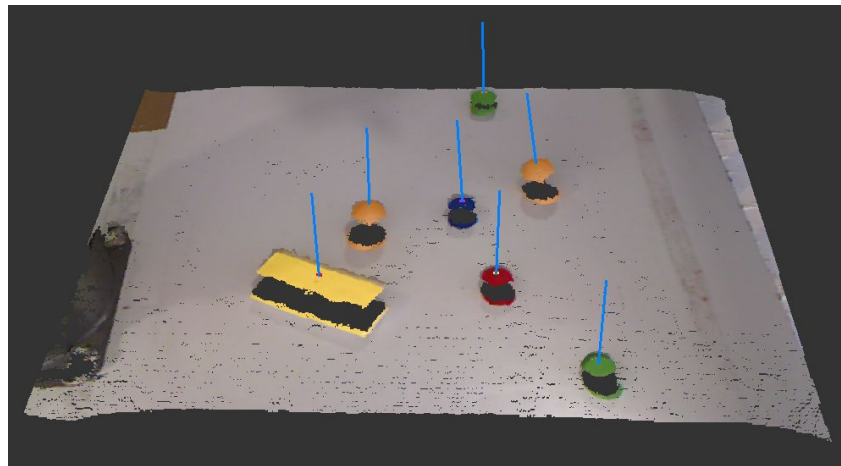
Centroide e Normal de Cada Objeto



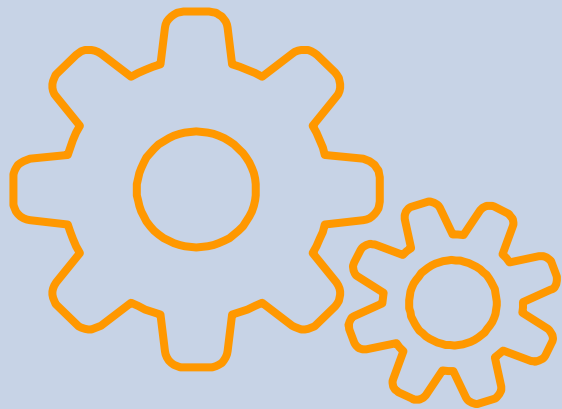
- Normal de todos os pontos;
- Centróide dos pontos de cada *cluster* (*Centróide Virtual*);
- Determinação, em cada *cluster*, do ponto mais próximo do centróide virtual (*Centróide da Superfície*);
- Normal do Centróide da Superfície.

Diferenciação dos pontos em diferentes *clusters* que correspondem a cada objeto.

Nuvem de Pontos Inicial com Centróide e Normal Assinalados



4



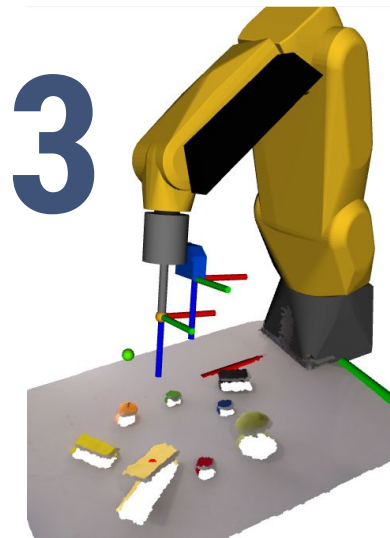
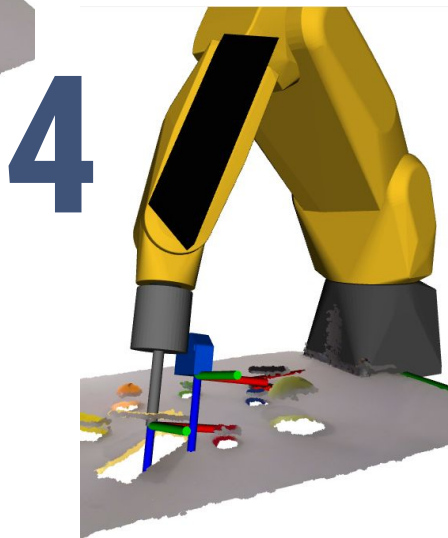
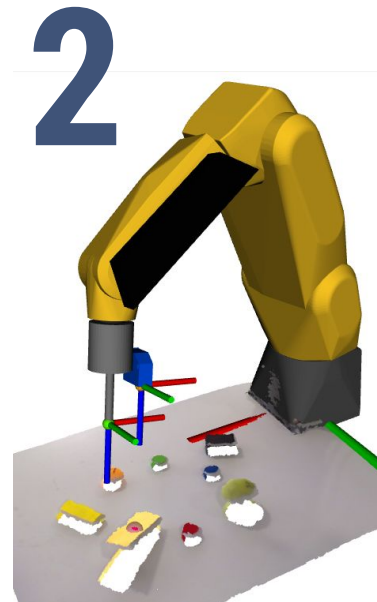
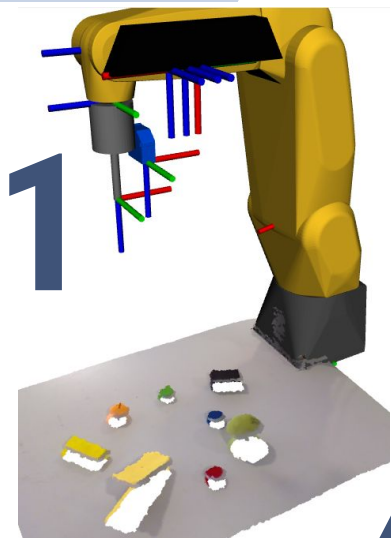
INTEGRAÇÃO DO SISTEMA

Análise do Espaço de Trabalho

Medição da Distância com o Sensor Laser

Deslocação para *Grasping Point*

Deslocação para Ponto de Aproximação



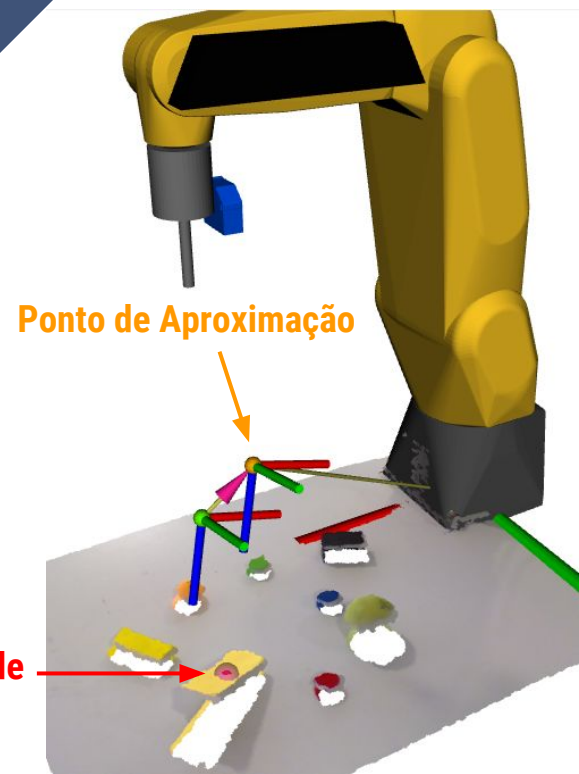
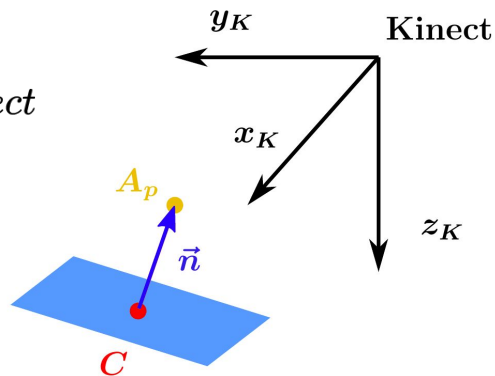


1ª POSIÇÃO - ANÁLISE

$$\text{Centroide}_{Kinect} + \text{Normal}_{Kinect}$$

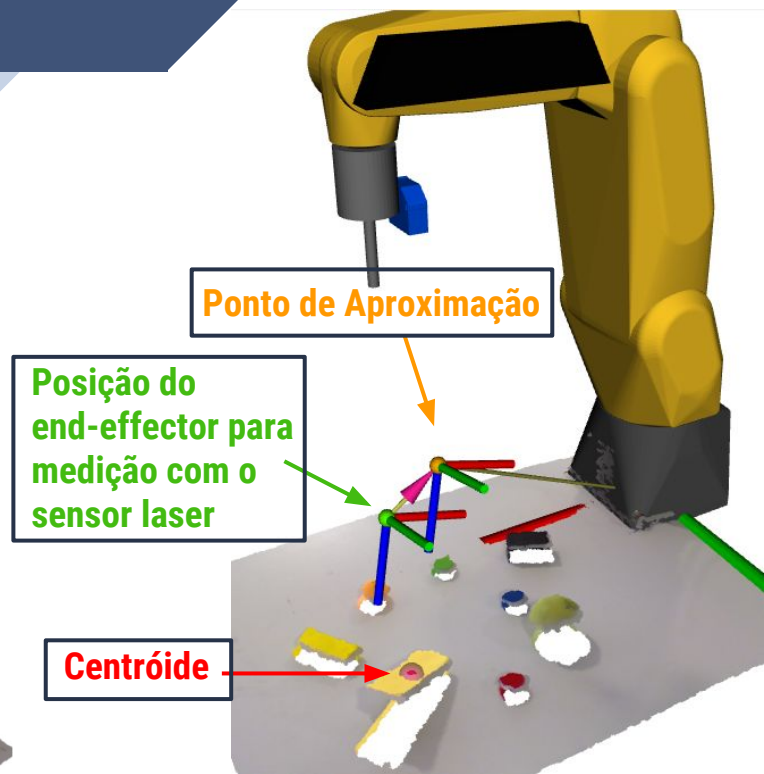
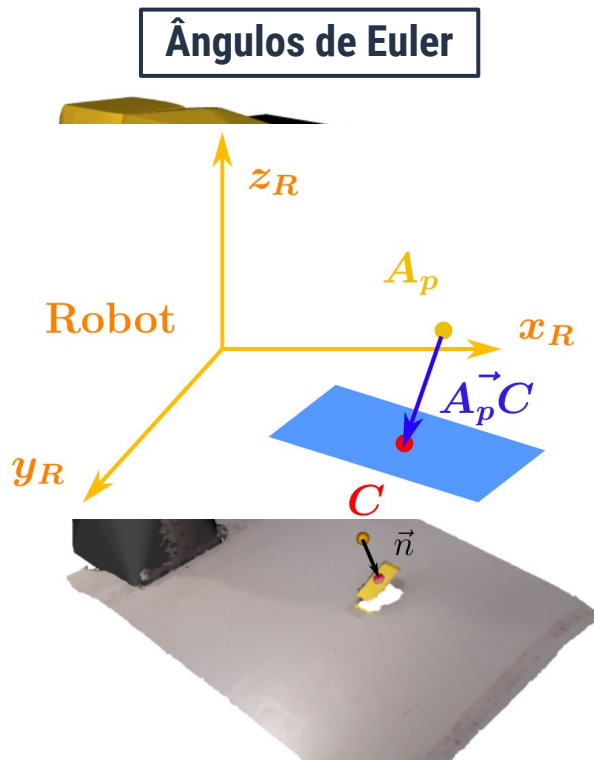
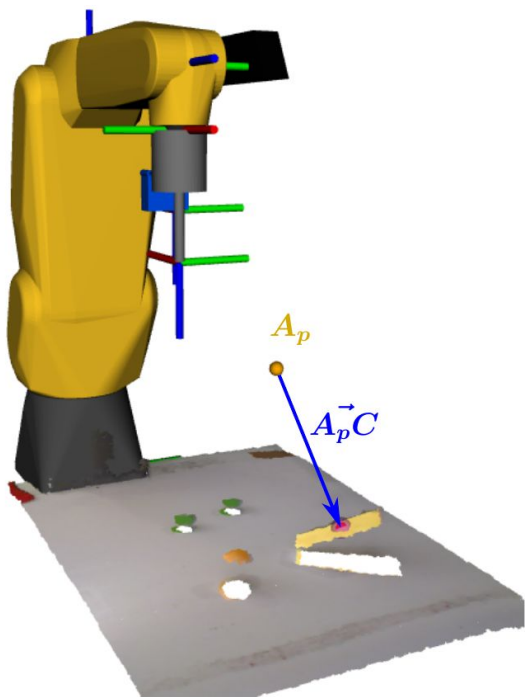
C \vec{n}

Ponto de Aproximação_{Kinect}
 A_p



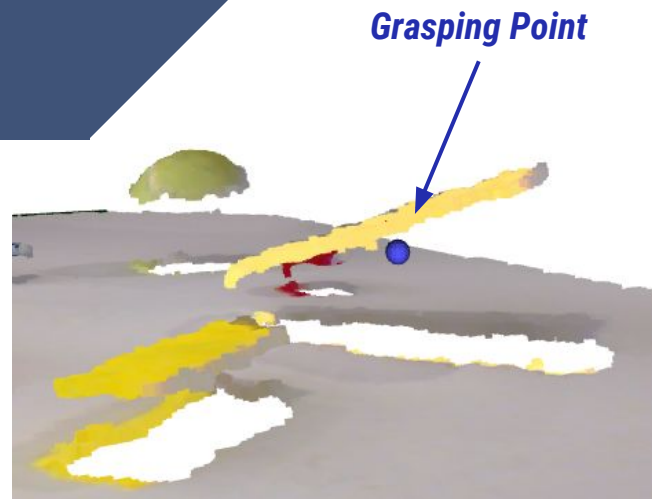
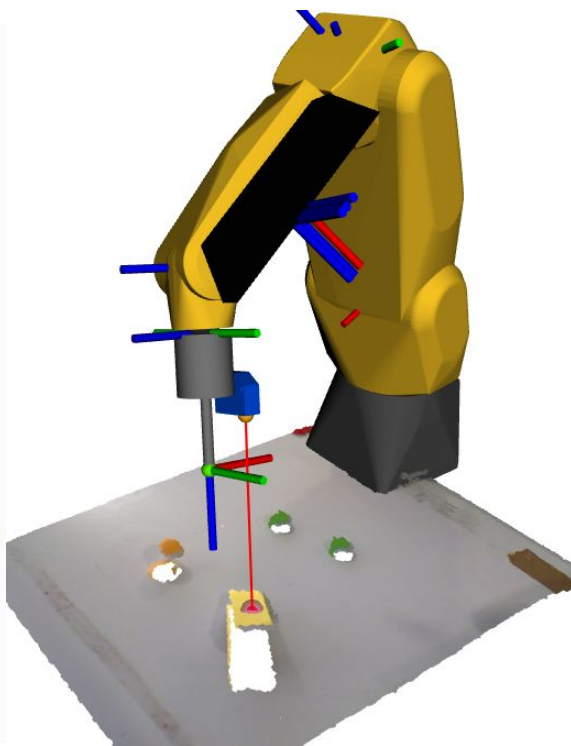


1ª POSIÇÃO - ANÁLISE





2ª POSIÇÃO - MEDIÇÃO DISTÂNCIA

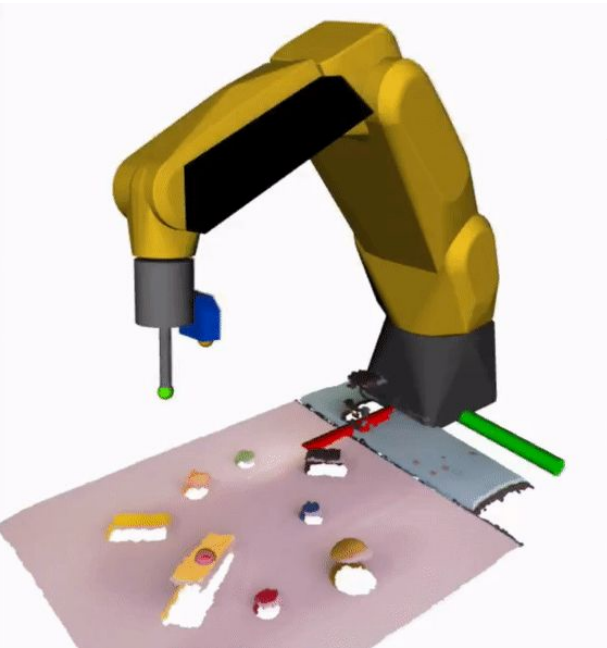


Determinação do *Grasping Point*

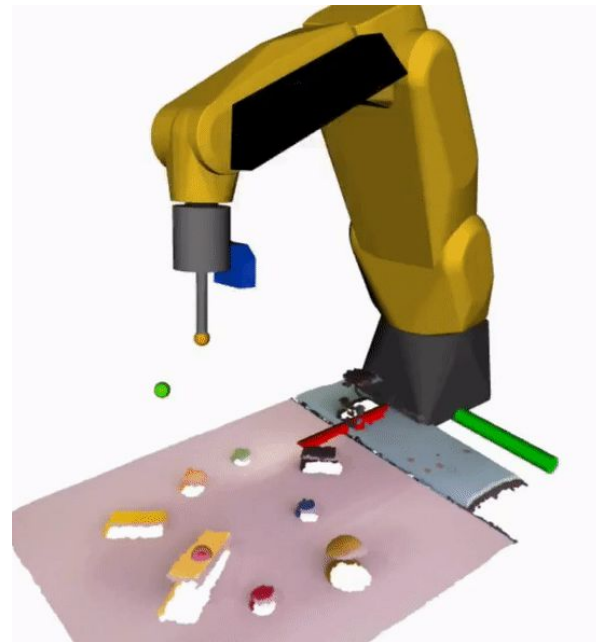
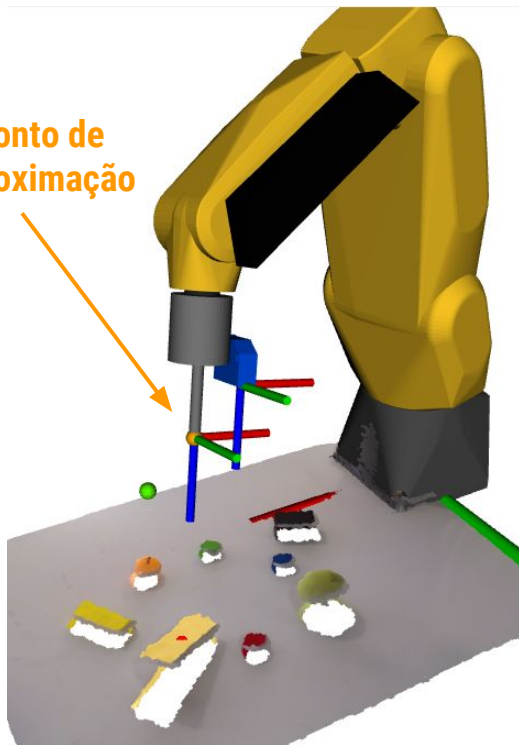
$$G_p = A_p + laser_reading \times \widehat{A_p C}$$



3ª POSIÇÃO - PONTO DE APROXIMAÇÃO

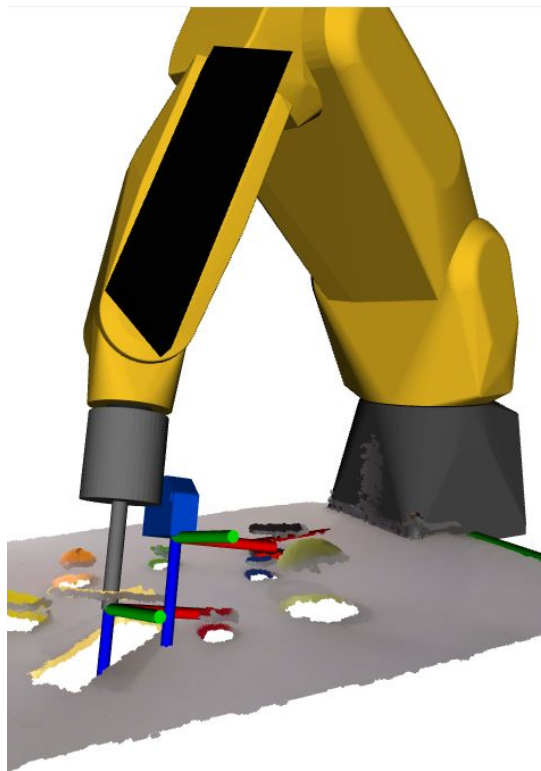


Ponto de Aproximação

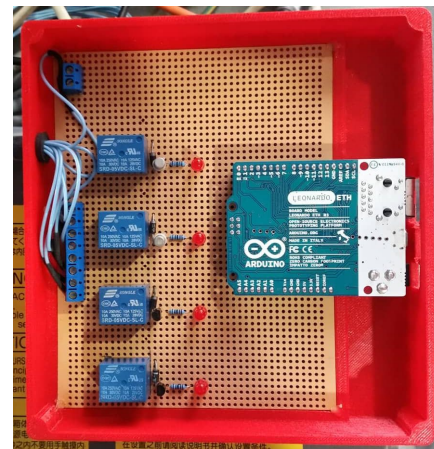




4ª POSIÇÃO - GRASPING POINT

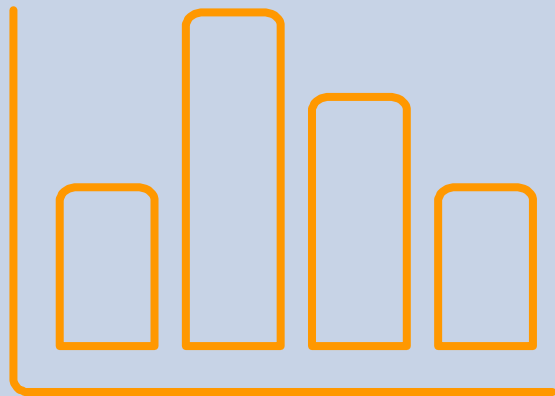


Unidade de Controlo para Activação dos I/Os



[1] Vítor Silva. "Integração de Manipulador FANUC na Plataforma Robuter para Manipulação Móvel". MSc Thesis. Universidade de Aveiro, 2017

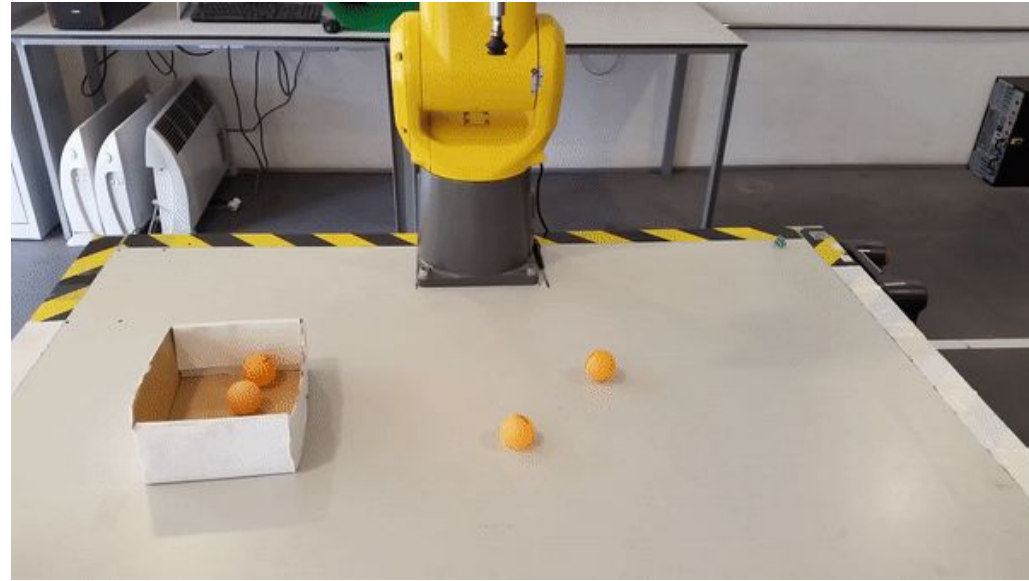
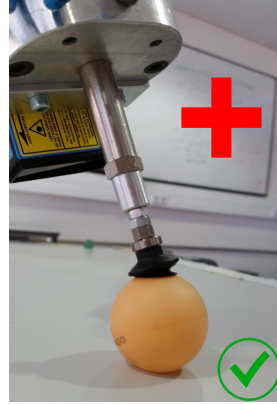
5



TESTES E RESULTADOS

Testes Iniciais

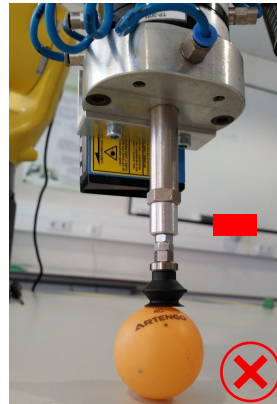
Normal



Leitura
Distância

20
Amostras
70 % sucesso

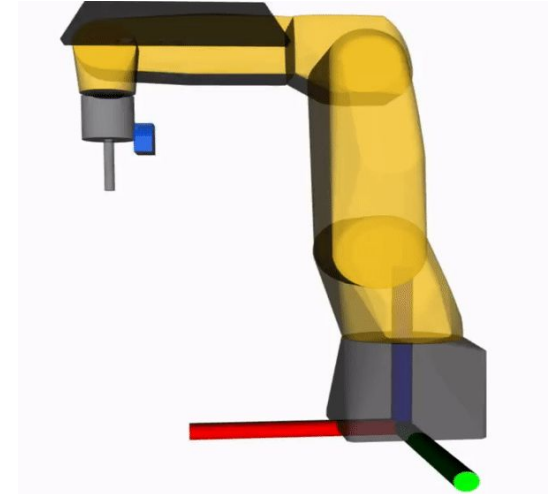
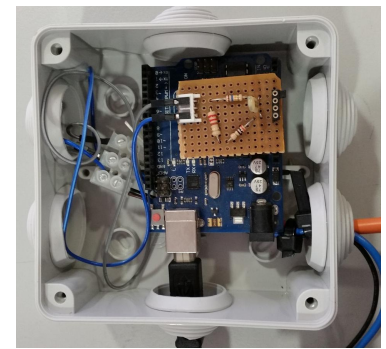
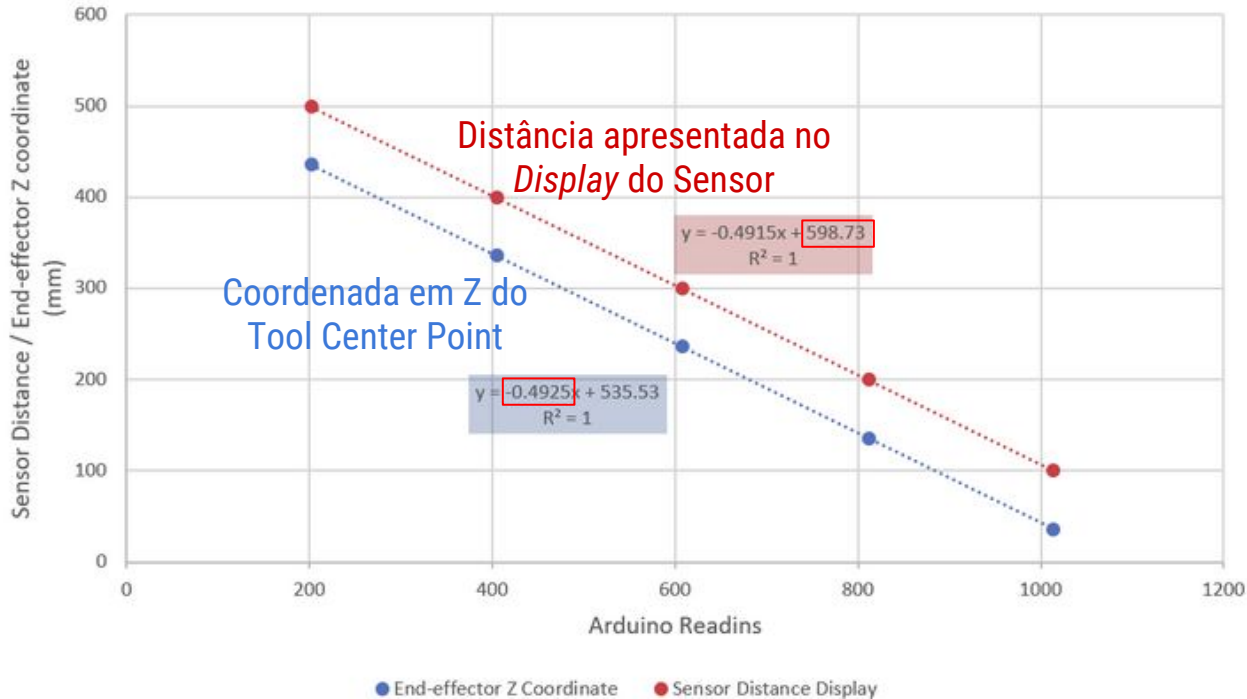
Centróide



Aperfeiçoar as Leituras do Sensor

Recalibração da Curva da Conversão das Leituras do Sensor

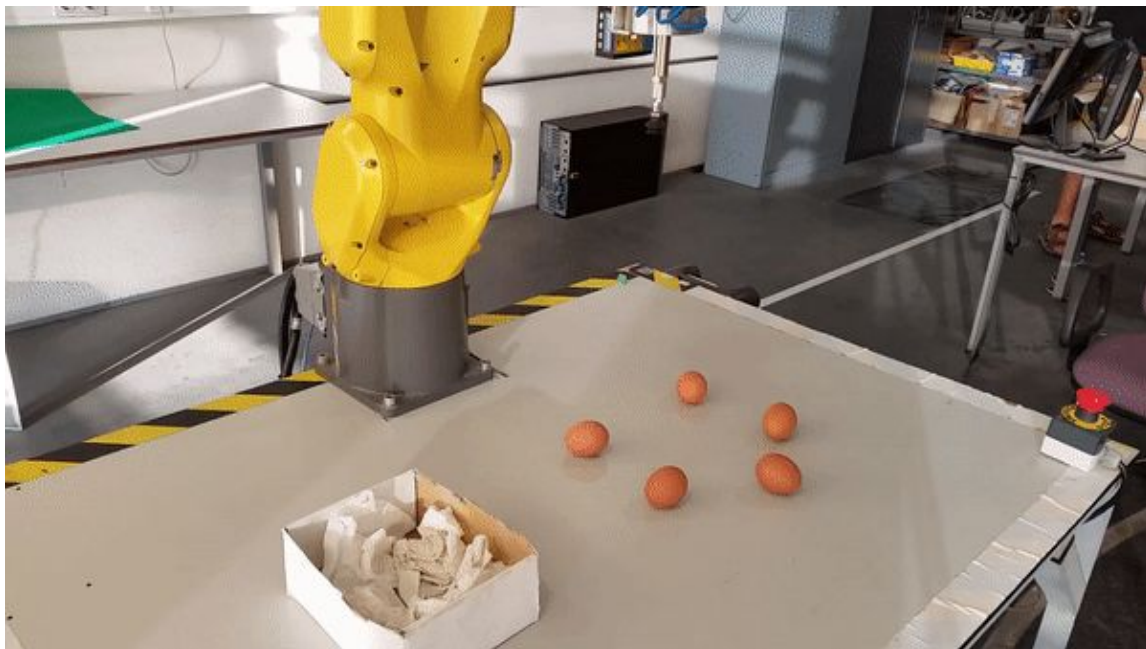
Curve to convert Arduino readings in Distance



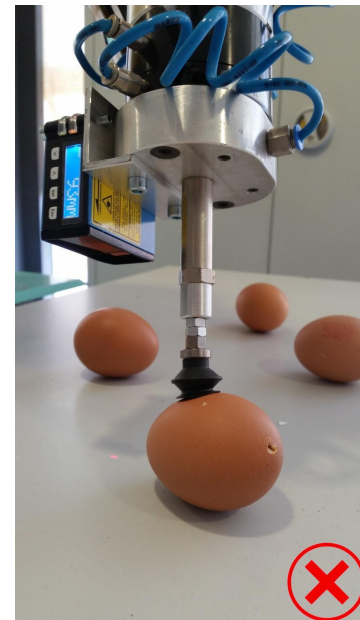
Testes com Objetos Frágeis

20 Amostras

90% sucesso - 0 Ovos Partidos

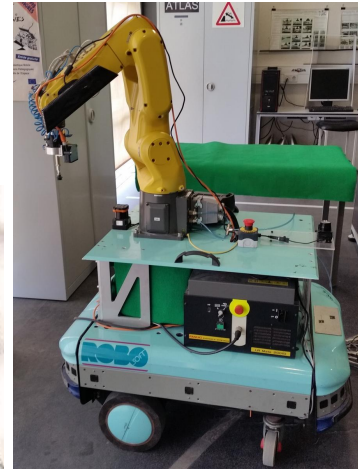


Normal

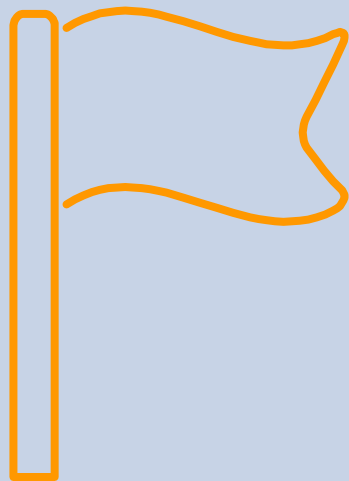


Demonstração com Plataforma ROBONUC

Unidade de percepção ativa



6



CONCLUSÕES E TRABALHOS FUTUROS

Conclusões

- Hardware devidamente instalado e calibrado;
- Correcta combinação da informação dos 2 sensores para a determinação precisa do *Grasping Point*;
- Desenvolveu-se um processo viável de 4 etapas;
- A Kinect apesar de económica não é recomendável para o uso num meio mais industrial.

Trabalhos Futuros

- Melhorar a segmentação;
- Determinar mais do que um *Grasping Points* para objetos maiores;
- Tornar a plataforma ROBONUC móvel.



**Obrigada pela vossa
atenção!**