Active Binocular System for Simultaneous Localization and Mapping (SLAM)

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Motivation

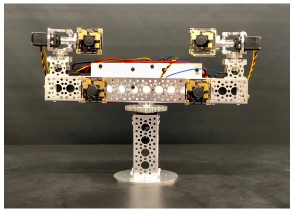
- **SLAM**: construct environment within which simultaneously keep track of location.
- **Active perception**: manipulate camera viewpoint to investigate the environment, from which gain better information.
- Integrate Visual SLAM and Active perception to obtain better localization and mapping.

Methods and Techniques

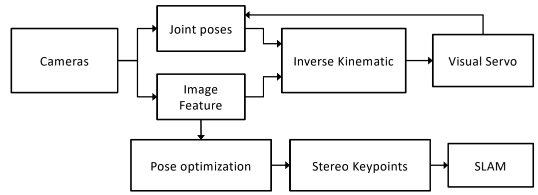
- **Visual Servo**: vision-based robot control.
- **Inverse Kinematic**: determine the parameters $\boldsymbol{q} = [q_2, q_3, q_4]$ for desired joint camera viewpoints from kinematic equations .
- vSLAM: SLAM with only visual input.

Overview of Hardware

- **4 Cameras**: two parallel, two rotatable.
- **5-DOF**: left and right camera pan-tilt (Four HS-5626MG Servos) and base pan (One HSR-2645CHR Servo), Servos are equipped with potentiometers for angular position state monitoring.
- **microcontroller**: Arduino Mega 2560, Control Servos and read potentiometers for joints' position measuring.
- **Power**: 4 pieces of NCR18650 Batteries and pololu 5V 15A voltage regulator.



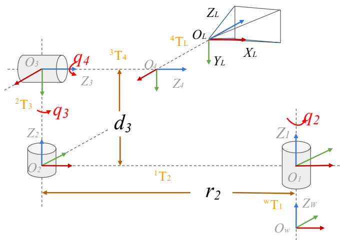
Overview of System



- Desired Pose for the system is for both camera gazing on feature-rich area.
- Relative pose between cameras needs optimization for determining precise stereo keypoints.
- Stereo keypoints are defined by three coordinates $\boldsymbol{x_s} = [\boldsymbol{u_L}, \boldsymbol{v_L}, \boldsymbol{H}]$, being H the tuple of 5 parameters for Essential matrix between two cameras.

Modeling

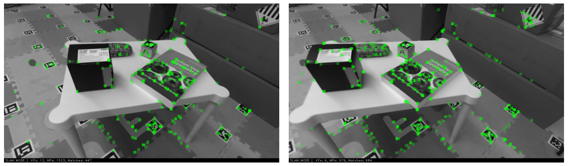
- Modelling kinematic parameters for Binocular system by applying **Denavit-Harternberg** (DH) method.
- Transformations between each intermediate coordinates (joints) are notated and determined.
- DH Parameters $[\boldsymbol{\theta}, \boldsymbol{\alpha}, \boldsymbol{d}, \boldsymbol{r}]$ are determined by measuring.
- $[\boldsymbol{q_2}, \boldsymbol{q_3}, \boldsymbol{q_4}]$ are desirable angular positions of 3 joints w.r.t. initial positions.



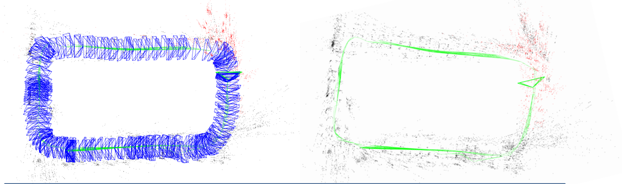
Trans	theta	alpha	d(mm)	r(mm)
$^1T_2$	q_2	0	0	136.91
$^2T_3$	$-\frac{\pi}{2}+q_3$	$-\frac{\pi}{2}$	53.5	0
$^3T_4$	q_4	0	44.35	0
$^1T_5$	q_2	0	0	136.91
$^5T_6$	$-\frac{\pi}{2}+q_3$	$-\frac{\pi}{2}$	53.5	0
$^6T_7$	q_4	0	−44.35	0

Qualitative Avenue

- Image ORB Feature Extraction Example



- SLAM with parallel camera pair



Ongoing Research

- Develop Feature-rich based visual servo strategy.
- Optimization for inaccurate transformations caused by loose potentiometers reading and kinematic measurement.

Future Work

- Refine image blurring caused by visual servo.
- Loop Closing for two cameras' covisibility graphs.
- Release two cameras from the base and have two independent cameras running SLAM jointly.

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Masters Opportunity for Research in Engineering

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