EECS 499 Project 1

Image Tracking

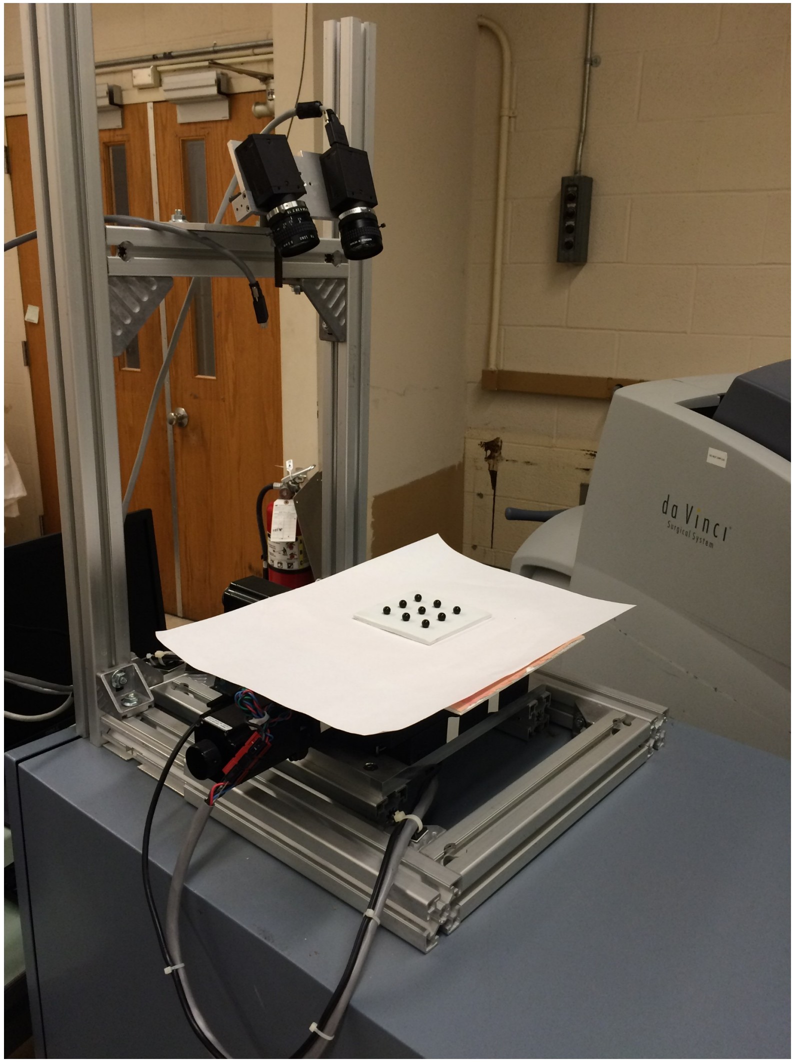
Su Lu

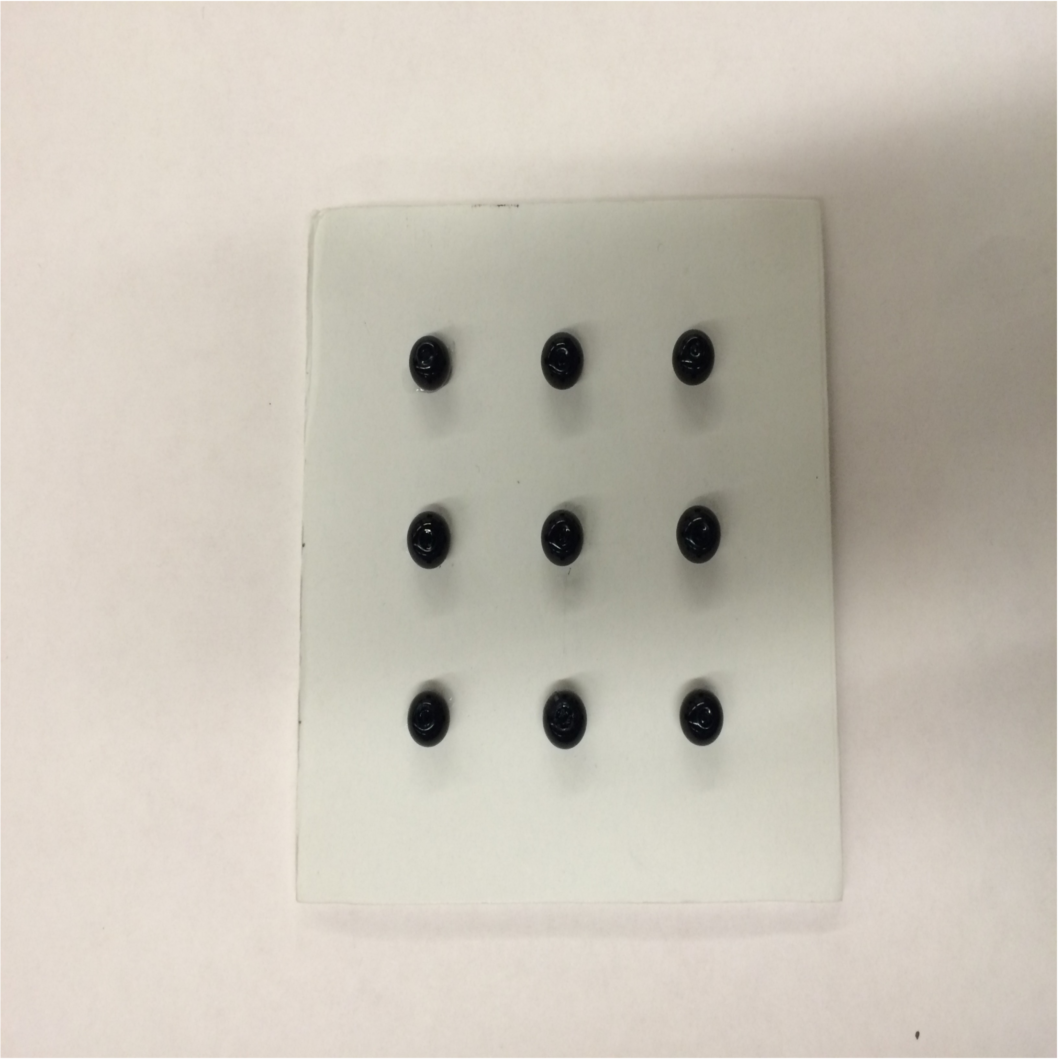
04/05/2016

Contents:

- **1. Background**
- **2. Experiment setup**
- **3. Particle filter implementation**
- **4. Result**
- **5. Improvement**

Experiment setup





Background

- Automatic suturing system on daVinci Robot
- Estimation of object deformationS
- Simplified 6-Dof rigid body motion (plate motion)
- Tracking plate motion by capturing beads motion (fiducials)
- ROS implementation

Particle filter implementation

- **State X_t: 6-Dof (x, y, z, rot_x, rot_y, rot_z) expressed by transformation matrix from body to camera frame G_{cb}**
- **Measurement Z_t: Camera Image**
- **Control U_t: Matrix exponential $e^{V_s t}$.**

  - V_s randomly generated spatial velocity
- **Each particle represented a hypothesized transformation matrix G_{cb} or an image with 9 beads**

line 4:

```
Eigen::Affine3d particle_trans_mat_update =
beadsGenerator.getNewTransformationMatrix(particles_set[i], delta_time);
```

line 5:

```
cv::matchTemplate(g_frame_in, expected_bead_pos_image, weight,
CV_TM_CCOEFF_NORMED);
```

line 8 – 11: Using low variance sampler

1: **Algorithm Particle_filter**($\mathcal{X}_{t-1}, u_t, z_t$)**:**
2: $\bar{\mathcal{X}}_t = \mathcal{X}_t = \emptyset$
3: for $m = 1$ to M do
4: sample $x_t^{[m]} \sim p(x_t \mid u_t, x_{t-1}^{[m]})$
5: $w_t^{[m]} = p(z_t \mid x_t^{[m]})$
6: $\bar{\mathcal{X}}_t = \bar{\mathcal{X}}_t + \langle x_t^{[m]}, w_t^{[m]} \rangle$
7: endfor
8: for $m = 1$ to M do
9: draw i with probability $\propto w_t^{[i]}$
10: add $x_t^{[i]}$ to $\mathcal{X}_t$
11: endfor
12: return $\mathcal{X}_t$

1: **Algorithm Low_variance_sampler**($\mathcal{X}_t, \mathcal{W}_t$)**:**
2: $\bar{\mathcal{X}}_t = \emptyset$
3: $r = \text{rand}(0; M^{-1})$
4: $c = w_t^{[1]}$
5: $i = 1$
6: for $m = 1$ to M do
7: $u = r + (m-1) \cdot M^{-1}$
8: while $u > c$
9: $i = i + 1$
10: $c = c + w_t^{[i]}$
11: endwhile
12: add $x_t^{[i]}$ to $\bar{\mathcal{X}}_t$
13: endfor
14: return $\bar{\mathcal{X}}_t$

Results

- **Failed to tracking random rigid body motion**

  Possible reasons:

  1. Number of particles too less (current 1000), need more?

  2. Initial particles guess not correct?

  3. Re-sample frequency, currently depend on delta time between loop, better to re-sample at fixed frequency 5s or 10s?

#	Message
#89002	Paritcle No. 20, normalized weight 0.001023
#89001	Paritcle No. 19, normalized weight 0.001023
#89000	Paritcle No. 18, normalized weight 0.001023
#88999	Paritcle No. 17, normalized weight 0.001023
#88998	Paritcle No. 16, normalized weight 0.001023
#88997	Paritcle No. 15, normalized weight 0.001023
#88996	Paritcle No. 14, normalized weight 0.001023
#88995	Paritcle No. 13, normalized weight 0.001023
#88994	Paritcle No. 12, normalized weight 0.001023
#88993	Paritcle No. 11, normalized weight 0.001023
#88992	Paritcle No. 10, normalized weight 0.001023
#88991	Paritcle No. 9, normalized weight 0.001023
#88990	Paritcle No. 8, normalized weight 0.001023
#88989	Paritcle No. 7, normalized weight 0.001023
#88988	Paritcle No. 6, normalized weight 0.001023
#88987	Paritcle No. 5, normalized weight 0.000002
#88986	Paritcle No. 4, normalized weight 0.001023
#88985	Paritcle No. 3, normalized weight 0.001023
#88984	Paritcle No. 2, normalized weight 0.001023
#88983	Paritcle No. 1, normalized weight 0.001023
#88982	Paritcle No. 0, normalized weight 0.001023

Improvements

- Tracking tissue deformation by particle filter
- Accurate Motion model by robot joint motion
- FEM Implementation to estimate soft tissue deformation