Object Classifying Concept

Start point

θ3_t

θ1_t

θ2_t

From touch
at point
(Xt, Yt, Zt)

Unknown Object

Apply small
movement
(Xm, Ym, Zm)

Soft Object

θ3_m

θ1_m   θ2_m

Object deformed

(Xm', Ym', Zm')
actual feedback

(Xm, Ym, Zm)
calculation expected

Unknown Object

Apply small
movement
(Xm, Ym, Zm)

Hard Object

θ3_m

θ1_m   θ2_m

Joint deformed

Object not deform

(Xm', Ym', Zm')
actual feedback

(Xm, Ym, Zm)
calculation expected

Unknown Object
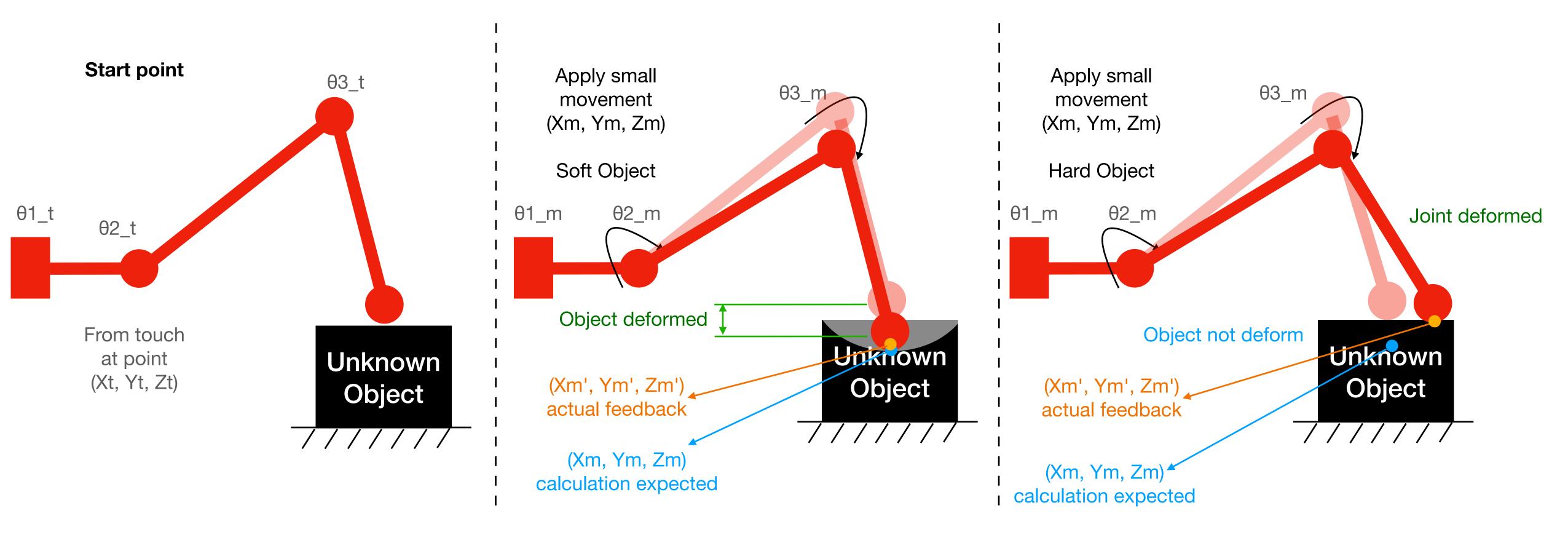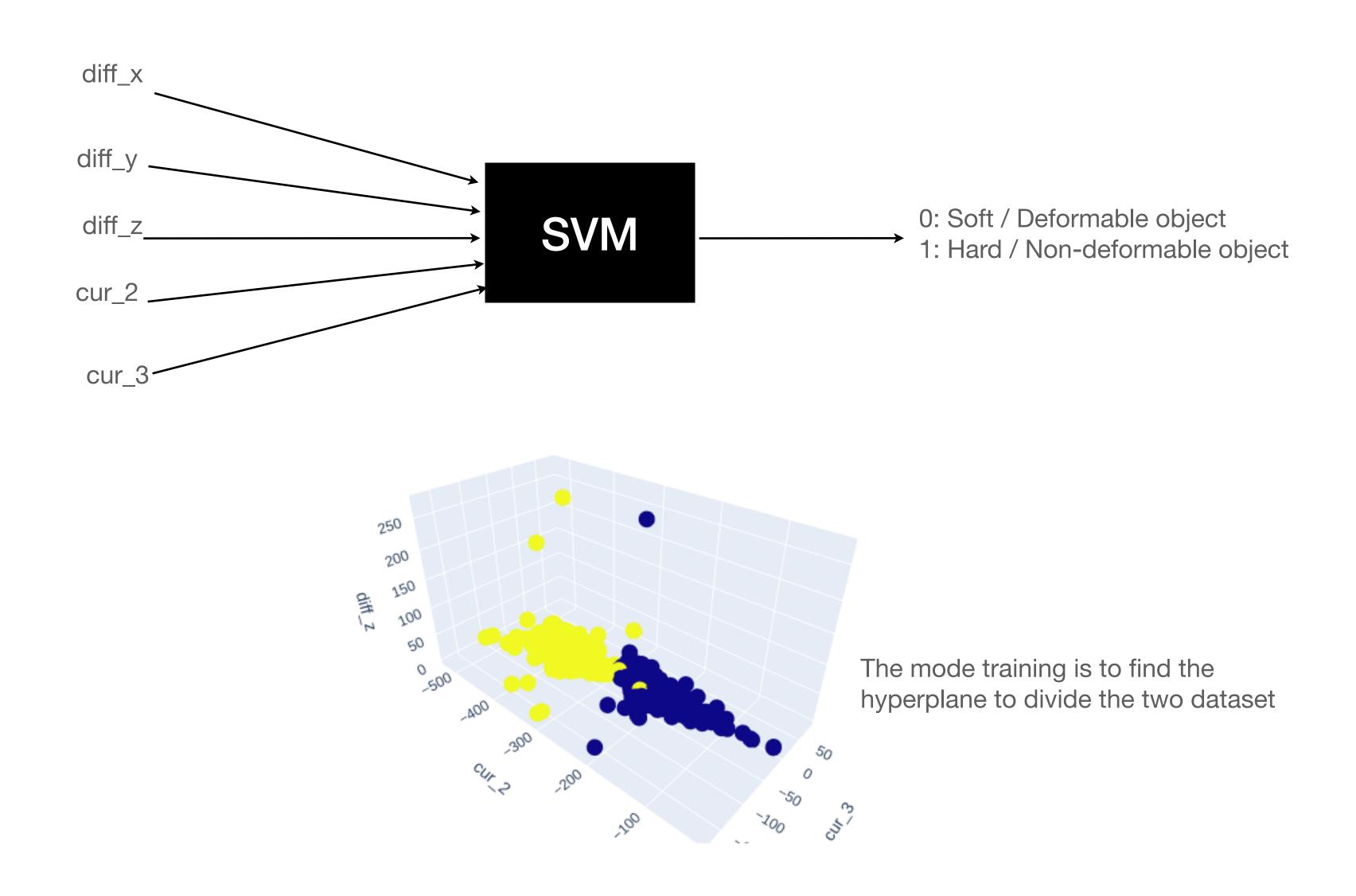

We know the kinematic variables of touch point, θ1_t, θ2_t, θ3_t, Xt, Yt, Zt
We know how much small movement we're going to apply, then θ1_m, θ2_m, θ3_m, Xm, Ym, Zm could be expected

If **Soft object (Deformable)**; the θ1_m, θ2_m, θ3_m should be as calculation expected. The leg tip should squeeze on object's surface and have
deformation or surface.
Meaning the result of actual θ1_m, θ2_m, θ3_m from servo feedback and result of θ1_m, θ2_m, θ3_m calculated shouldn't be too far from each other.

If **Hard object (Non-Deformable)**; The leg tip should squeeze on object's surface but deformation is appear on the leg's joints instead of object's surface.
Meaning the result of actual θ1_m, θ2_m, θ3_m from servo feedback and result of θ1_m, θ2_m, θ3_m calculated are far from each other. Because the force
from on leg tip couldn't defeat the reaction force from rigid body.

Machine Learning Model:
Support Vector Machine (SVM)

The mode training is to find the hyperplane to divide the two dataset
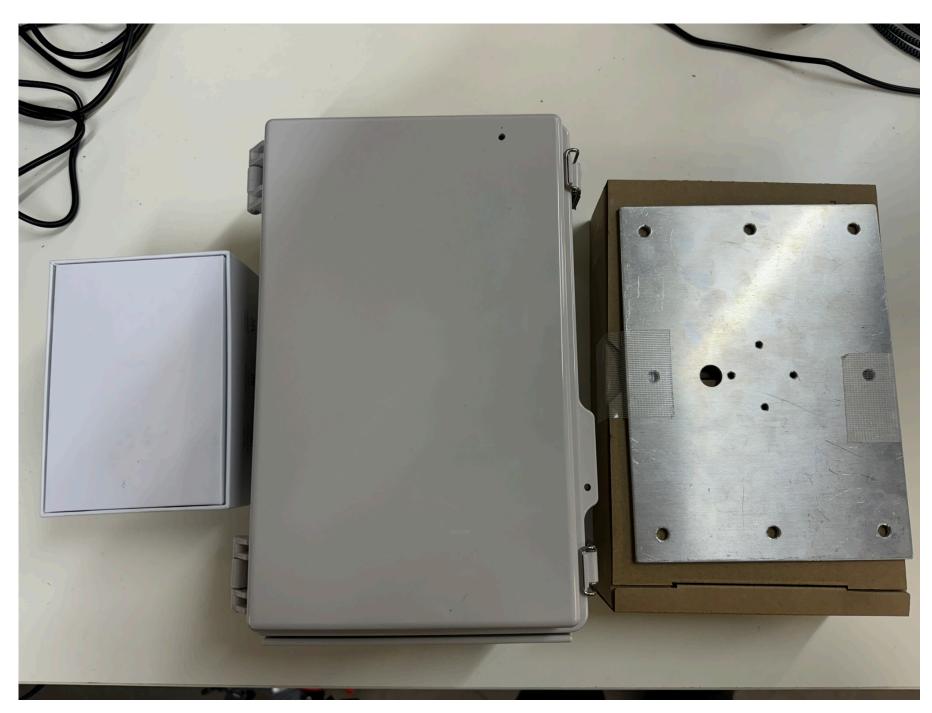
Object Candidates for Machine Learning

Soft Object (Deformable)

- plastic bubble
- foam
- sponge

Hard Object (Non-Deformable)

- package box
- control box
- aluminum plate

Data Collecting

Soft Object (Deformable)

	diff_x	diff_y	diff_z	cur_2	cur_3	output
0	2.008554	1.184993	5.634677	-185.610001	-2.690000	0
1	2.408477	1.236763	6.940285	-193.679993	-10.760000	0
2	2.929307	1.619215	9.250079	-204.440002	-16.139999	0
3	2.356147	1.781269	8.818315	-185.610001	-24.209999	0
4	2.398292	1.888242	6.837651	-209.820007	8.070000	0
...	...	...	...	...	...	...
312	3.375883	3.639172	10.029212	-285.140015	13.450000	0
313	3.206733	3.520131	9.569049	-269.000000	5.380000	0
314	2.950911	4.047875	10.929989	-269.000000	0.000000	0
315	0.869772	0.928631	2.154620	-29.590000	2.690000	0
316	3.008096	3.763740	10.368999	-274.380005	5.380000	0

Hard Object (Non-Deformable)

	diff_x	diff_y	diff_z	cur_2	cur_3	output
0	6.562722	4.925308	14.653786	-416.950012	-18.830000	1
1	7.840654	3.215452	15.686584	-411.570007	-29.590000	1
2	5.739485	2.481402	15.683270	-408.880005	-21.520000	1
3	4.932403	2.541826	14.740002	-357.769989	-64.559998	1
4	4.571026	2.326599	16.073137	-333.559998	-26.900000	1
...	...	...	...	...	...	...
319	3.480265	4.084238	13.330229	-484.200012	-67.250000	1
320	3.421402	3.888251	13.219278	-468.059998	-59.180000	1
321	5.036355	4.573036	12.439687	-519.169983	-91.459999	1
322	5.479415	4.446608	11.358766	-524.549988	-102.220001	1
323	4.670375	4.605954	12.630703	-481.510010	-88.769997	1

Noticeable Point

- hard object will have the differences of x,y,z much more than soft object

- current feedback will be less in soft object because object is deformed more than leg

Servo Configuration in Inspection Mode

- Leg2, Leg3 are used (servo id from 4 to 9)

- Servo is in Current-Based Position Control

- current limit is set to 500 (in unit of 2.69 mA)

- PID gains are (300, 20, 2000)

- touch criteria, servo 5 or 8 has reverse current more than 30

(in unit of 2.69 mA)

- inspection surface pressing depth 20mm

Inspection Mode Algorithms

```
┌─────────────────────────┐
│       Do touch          │◄──────┐
│  by push the leg down   │       │ not
└─────────────────────────┘       │ touched
             │                     │ yet
             ▼                     │
┌─────────────────────────┐       │
│   Surface touch check   │───────┘
│   by current feedback   │
└─────────────────────────┘
             │ touched
             ▼
┌─────────────────────────┐
│      Do inspection      │◄──────┐
│  by push the leg down   │       │ not
└─────────────────────────┘       │ reached
             │                     │ yet
             ▼                     │
┌─────────────────────────┐       │
│ Reach 20mm depth check  │───────┘
└─────────────────────────┘
       │ reached    │
       ▼            ▼
┌──────────────┐  ┌──────────────┐
│Compare present│  │Measure the   │
│pose with      │  │current       │
│expected pose  │  │on servo      │
└──────────────┘  └──────────────┘
       │            │
       ▼            ▼
┌─────────────────────────────────────┐
│ Pass position differences and        │
│ current data to SVM                  │
│ Machine Learning model to predict/   │
│ train                                │
└─────────────────────────────────────┘
             │
             ▼
   0: Soft / Deformable object
   1: Hard / Non-deformable object
```