**Implementation Results for Combined Uncertainty**

**Sampled\_Position\_X** = [0.50162274, 0.48951069, 0.50341215, 0.49615727, 0.48101159, 0.47225563,  
 0.501272, 0.48676327, 0.46111212, 0.47396221, 0.48636629, 0.49040326,  
 0.49434653, 0.48770368, 0.49803126, 0.48269194, 0.4861956, 0.47861138,  
 0.4871818, 0.47833452, 0.49097439, 0.49541848, 0.49616701, 0.49587376,  
 0.48589114, 0.48176583, 0.50880319, 0.50292152, 0.49137836, 0.48756908,  
 0.49160862, 0.49258558, 0.4923422, 0.5045687, 0.48087306, 0.50729335,  
 0.49387115, 0.48184728, 0.48098471, 0.48100386, 0.47912577, 0.48962986,  
 0.49796531, 0.49139124, 0.50437722, 0.47272433, 0.46046471, 0.50886724,  
 0.47090171, 0.48231243]  
**Sampled\_Position\_Y** = [0.00583692, -0.00183908, 0.01022704, 0.01272923, 0.01383809, -0.00853211,  
 -0.00863691, 0.00434802, 0.0148004, -0.0062895, -0.00249842, 0.01237284,  
 0.01789194, 0.00260495, 0.00278459, 0.01536117, -0.00491076, 0.00727189,  
 -0.01302764, -0.00467967, -0.0046506, 0.00556309, -0.00939853, 0.00011278,  
 0.01854924, 0.00540417, 0.00649814, 0.02043808, -0.00225368, -0.00759682,  
 0.00524199, 0.01498114, -0.00356128, -0.00178039, 0.01685438, 0.00172228,  
 -0.00232857, 0.0112997, 0.01051437, -0.00626076, 0.00211887, 0.01688476,  
 0.00964298, 0.00292617, 0.0043659, -0.00725703, 0.01913036, 0.01320721,  
 0.00547154, -0.00220461]  
**velocities** = [0.42703107, 0.65054628, 0.92381211, 0.88242321, 0.06409533, 0.51991044,  
 0.43203649, 0.27483223, 0.83336267, 0.02550827, 0.75090269, 0.02264429,  
 0.65405846, 0.66280533, 0.56989851, 0.68723757, 0.86994983, 0.36043064,  
 0.34402646, 0.65436021, 0.6591422, 0.78463515, 0.88210962, 0.72336961,  
 0.25443845, 0.76279022, 0.46886211, 0.36765262, 0.59939354, 0.30912722,  
 0.66781543, 0.30594075, 0.06743806, 1.00547776, 0.391729, 0.3916542,  
 0.37883287, 0.7622545, 0.46375612, 0.5830149, 0.69778815, 0.35644257,  
 0.13074546, 0.04309196, 0.35561919, 0.0730527, 0.12520682, 0.14678731,  
 0.3663727, 0.76891574]  
**accelerations** = [0.0467997, 0.35615545, 0.17009115, 0.24398892, 0.4896305, 0.01974982,  
 0.94418495, 0.43542593, 0.96057379, 0.08151943, 0.23918518, 0.97230289,  
 0.94863992, 0.92756688, 0.03830152, 0.24073922, 0.74912436, 0.48310211,  
 0.46059096, 0.39073863, 0.51503254, 0.30436251, 0.3912778, 0.46240073,  
 0.53232177, 0.28667387, 0.08246239, 0.96527791, 0.83631219, 0.31838201,  
 0.25881522, 0.25272922, 0.48158767, 0.93534967, 0.39018217, 0.37232855,  
 0.54877344, 0.21277038, 0.8446034, 0.3901857, 0.8445308, 0.60013632,  
 0.19664784, 0.19792021, 0.66873008, 0.40150629, 0.82411241, 0.2059014,  
 0.66412756, 0.33099307]  
**gripper\_width** = [0.02684837, 0.0234594, 0.03962826, 0.0201221, 0.02268935, 0.02526456,  
 0.03840064, 0.02629163, 0.03076169, 0.03627818, 0.03557461, 0.03887616,  
 0.03899043, 0.02357946, 0.02643949, 0.03110151, 0.02843104, 0.02843928,  
 0.03842656, 0.03544561, 0.03413455, 0.02764091, 0.02018796, 0.03905807,  
 0.03845678, 0.02295339, 0.03321773, 0.029642, 0.02133097, 0.03390705,  
 0.02423955, 0.02086985, 0.03394813, 0.02635472, 0.02848267, 0.0318311,  
 0.03684087, 0.03400123, 0.02787337, 0.02904743, 0.03712919, 0.03479383,  
 0.03875053, 0.03995893, 0.02000533, 0.03913015, 0.02350454, 0.02574158,  
 0.02528663, 0.03632591]

**Scenario 1:** Uncertainty in Object Position and Gripper Width  
In this scenario, uncertainty is introduced in both the object's X and Y positions as well as the gripper width, while velocity and acceleration are kept constant.

* For object position, a Normal distribution with a standard deviation of 0.01 was applied to generate the X and Y values.
* For the gripper width, uncertainty was modelled using a Uniform distribution with a scale of 0.01

The success rate in this scenario was 52%, indicating a moderate level of task success under combined uncertainties in object position and gripper width.

**Scenario 2:** Uncertainty in Object Position, Velocity, and Acceleration  
In this case, uncertainty was introduced in the object’s X and Y positions, as well as in velocity and acceleration, while the gripper width remained constant.

* The object's X and Y coordinates were generated using a Normal distribution with a standard deviation of 0.01.
* Velocity uncertainty was modelled using a Normal distribution with a standard deviation of 0.3 around a mean velocity of 0.5 m/s.
* Acceleration uncertainty was introduced using a Uniform distribution with a scale of 0.5.

Under these conditions, the robot achieved a success rate of 80%, demonstrating its resilience to uncertainty in these motion parameters.

**Scenario 3:** Combined Uncertainty in Object Position, Gripper Width, Velocity, and Acceleration  
In the final scenario, uncertainty was introduced across all four parameters: object position, gripper width, velocity, and acceleration.

* For object position, a Normal distribution with a standard deviation of 0.01 was used to generate the X and Y values.
* Gripper width uncertainty was modeled using a Uniform distribution with a scale of 0.01.
* Velocity uncertainty was modeled using a Normal distribution with a standard deviation of 0.3 around a mean velocity of 0.5 m/s.
* Acceleration uncertainty was generated using a Uniform distribution with a scale of 0.5.

The success rate in this scenario was 50%, reflecting a notable drop in performance when all four parameters were subjected to uncertainty simultaneously.

|  |  |  |
| --- | --- | --- |
| **Scenario** | **Success (%)** | **Failure (%)** |
| Object Position + Gripper Width | 52% | 48% |
| Object Position + Velocity +  Acceleration | 80% | 20% |
| Object Position + Gripper Width + Acceleration +Velocity | 50% | 50% |

