ROTATION REPEATABILITY BENCHMARK

Reference No / Version	RAL-SI-2020-B19-0838_6-V1.0 For the latest versions of the benchmark, please refer to http://newdexterity.org/benchmarking/
Authors	Geng Gao[1], Gal Gorjup[1], Ruobing Yu[2], Patrick Jarvis[2], and Minas Liarokapis[1]
Institution	[1]University of Auckland, [2]Humanoid Artificial Intelligence
Contact Information	ggao102@aucklanduni.ac.nz, ggor290@aucklanduni.ac.nz, ruobingy@aidatainnovations.com, patrickj@aidatainnovations.com, m.liarokapis@auckland.ac.nz
Adopted Protocol	Any protocol that involves periodic object rotation (RAL-SI-2020-P19-0838_2-V1.0, RAL-SI-2020-P19-0838_3-V1.0, RAL-SI-2020-P19-0838_4-V1.0).
Scoring	Assessment is based on the cycle end point variation. For each recorded periodic manipulation motion: 1) Isolate motion cycle start and end points. 2) Compute the average drift quaternion $\bar{\mathbf{q}}$ (Benchmark RAL-SI-2020-B19-0838_4-V1.0) and subtract it from subsequent endpoints to eliminate linear drift. For endpoints $i = 1 \dots n$, the corrected orientations $\mathbf{q}'_i$ are obtained through the following procedure: $\mathbf{q}'_1 = \mathbf{q}_1$ $\mathbf{q}'_i = \left(\text{inv}(\bar{\mathbf{q}}) \times \left(\mathbf{q}_i \times \text{inv}(\mathbf{q}'_{i-1})\right)\right) \times \mathbf{q}'_{i-1}, \quad \text{for} \quad i = 2 \dots n$ 3) Compute corrected rotation mean $\bar{\mathbf{q}}'$ as the eigenvector corresponding to the largest eigenvalue of matrix $\mathbf{M} = \sum_{i=1}^{n} \mathbf{q}'_i \mathbf{q}'^T_i$. 4) Compute sample angle variance $\sigma^2 = \sum_{i=1}^{n} \text{angle}\left(\mathbf{q}'_i, \bar{\mathbf{q}}'\right)^2 / (n-1)$, where the angle difference is computed through: $\text{angle}(\mathbf{p}, \mathbf{q}) = 2\cos^{-1}\left(\text{real}(\mathbf{p} \times \text{inv}(\mathbf{q}))\right)$. 5) the angle standard deviation from the variance: $\sigma = \sqrt{\sigma^2}$. The resulting standard deviation σ characterizes the angular spread of the manipulation motion end points. A lower score corresponds to better repeatability. The computation is performed for every sensorized object.
Details of Setup	To assist with data processing and metric computation, code samples are provided.
Results to Submit	For each sensorized object and manipulation motion: • Sensorized object type, size, and surface. • Sensorized object mass and center of mass (internal weight configuration). • Assessed hand model, aperture and control details. • Computed standard deviation σ. • Plots of recorded point clouds with highlighted cycle end points. • Comments on obtained results with respect to the hand model and control.