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# UNIFORM TASK LEVEL DEFINITIONS FOR ROBOTIC SYSTEM PERFORMANCE COMPARISONS

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ABSTRACT

The following is an initial effort to tabulate a series of 10 task levels of increasing difficulty on which to make comparative performance evaluations of available and future robotics technology. It is not certain that these 10 levels are sufficient or that they are in the correct order. Further, the specific detailed parameters of the tasks will have to be carefully outlined (perhaps by a workshop) by the affected community. These parameters have to do with relative scales, size of obstacles, size of task boards, oscillations of the task board support (frequency and amplitude), disturbance levels in process tasks, etc.

Note that each level has a breakdown of 10 additional levels of difficulty to provide a layering of 100 levels. It is assumed that each level of task performance must be achieved by the system before it can be appropriately considered for the next level.

Obviously, the community will wish to react to this as a point of departure. Nonetheless, something of this nature is necessary to drive the technology forward. Note that questions of mobility, portability, etc. are implied but perhaps should be set aside as additional requirements depending on the implied task regime. For example, zero G would be such a task regime as would 50 G, but they are so unique as to require a special community response.

Some members of the community would like to bypass or step over some of the task levels. This could be achieved by using the notation of 8.3 - 4, meaning that the system was proven at level 8.3 but all levels 5 through 7 were untested. Also, the community might like an up-to-10 level designation such as 1.6, 2.3, 3.4, 4.7, 5.4, which would imply testing within each listed task level to the decimal level of difficulty.

1. EXISTING STANDARD TASK BOARD SCALE (20% of Work Volume)

    1.0 Simple Placement
    1.1 Low Tolerance Peg-in-Hole
    1.2 High Tolerance Peg-in-Hole
    1.3 Bayonet Lock Assembly
    1.4 Toggle Lock Clamping Device
    1.5 Screwing of Nut on Bolt
    1.6 Force Fit Disassembly
    1.7 Force Fit Assembly
    1.8 Pin Connector Assembly
    1.9 Bending of Tube to Shape

2. ENLARGE TASK BOARD TO TAKE UP MOST (80%) OF ROBOT WORK VOLUME INCLUDING SPACES WITH SINGULARITIES

   2.0 Simple Placement
   2.1 Low Tolerance Peg-in-Hole
   2.2 High Tolerance Peg-in-Hole
   2.3 Bayonet Lock Assembly
   2.4 Toggle Lock Clamping Device
   2.5 Screwing of Nut on Bolt
   2.6 Force Fit Disassembly
   2.7 Force Fit Assembly
   2.8 Pin Connector Assembly
   2.9 Bending of Tube to Shape

3. TASK BOARD WITH SEVERAL PERPENDICULAR SURFACES WITH TASKS ON ALL SURFACES

   3.0 Simple Placement
   3.1 Low Tolerance Peg-in-Hole
   3.2 High Tolerance Peg-in-Hole
   3.3 Bayonet Lock Assembly
   3.4 Toggle Lock Clamping Device
   3.5 Screwing of Nut on Bolt
   3.6 Force Fit Disassembly
   3.7 Force Fit Assembly
   3.8 Pin Connector Assembly
   3.9 Bending of Tube to Shape

4. INCLUDE MOVEMENT OF THE TASK BOARD

   4.0 Small Sinusoidal Motion (1 DOF)
   4.1 Small Sinusoidal Motion (2 DOF)
   4.2 Variable (medium scale) Sinusoidal Amplitudes
   4.3 Random Small Motions (1 DOF)
   4.4 Random Small Motions (1 DOF and 2 DOF)
   4.5 Random Medium Scale Motion (1 DOF)
   4.6 Random Medium Scale Motion (2 DOF)
   4.7 Random Medium Scale Motion with Superimposed Small Shocks
   4.8 Large Scale Motion As in Floating in Ocean Currents or on Ocean Waves ($\omega$ < time scale)
   4.9 Random Large Scale Motion

| | |
|---|---|
| Small | - 1% of scale |
| Medium | - up to 5% of scale |
| Large | - up to 20% of scale |
| Sinusoidal | - $\omega \geq$ 5x time scale |

5. TRACKING OF PRESCRIBED SPATIAL PATHS

   5.0 Point-to-Point Tracking in Discrete Steps
   5.1 Straight Line Following
   5.2 Straight Line Following Along Major Workspace Dimension
   5.3 Circular Arc Following
   5.4 Circle Tracking With Round Out

5.5 Conic Section Curve Following
5.6 Flat Plane Following in 80% of Workspace
5.7 Spherical Surface Following in 80% of Workspace
5.8 Tracking Error of 0.1% of Scale
5.9 Tracking Error of 0.01% of Scale

6. OCCLUSION-VISUAL ACCESS IS DEGRADED

6.0 5% Visual degradation
6.1 15% Visual degradation
6.2 25% Visual degradation
6.3 35% Visual degradation
6.4 45% Visual degradation
6.5 55% Visual degradation
6.6 65% Visual degradation
6.7 75% Visual degradation
6.8 85% Visual degradation
6.9 95% Visual degradation

7. OBSTACLE STREWN ENVIRONMENT

7.0 One spherical obstacle in the environment, 10% of workspace in size
7.1 One spherical obstacle in the environment, 30% of workspace
7.2 One spherical obstacle in the environment, 50% of workspace
7.3 Straight line obstacle through workspace
7.4 Cylindrical obstacle with diameter 10% of workspace scale
7.5 Sphere of 10% and cylinder of 10% scale in workspace
7.6 Two spheres and two cylinders of 10% scale in workspace
7.7 Two spheres and two cylinders at 10% scale in workspace moving at 0.1 time scale of needed task performance time in 10% scale range of motion
7.9 Robot must reach through a ring of 20% scale of the workspace within 20% scale of the task objective
7.9 Robot must reach through a ring of 20% scale of the workspace within 50% scale of the task objective

8. OPERATION IN POTENTIAL FIELD FORCES

8.0 No external forces acting on robot structure
8.1 Effect of stream forces on end-effector - 10% of payload
8.2 Effect of stream forces on end-effector - 50% of payload
8.3 Effect of stream forces on end-effector - 90% of payload
8.4 Stream forces acting on all robot links - 10% effective payload
8.5 Stream forces acting on all robot links - 50% effective payload
8.6 Stream forces acting on all robot links - 90% effective payload
8.7 Base excited inertia forces acting on robot - 10% effective Payload
8.8 Base excited inertia forces acting on robot - 50% effective payload
8.9 Base excited inertia forces acting on robot - 90% effective payload

9. MULTIPLE ARM OPERATION

9.0 One arm fixed as holder
9.1 Both arms equal in performance
9.2 One arm 5 times greater in payload
9.3 Relative forces between end-effectors 10% of payload of weakest
9.4 Relative forces between end-effectors 50% of payload of weakest
9.5 Relative forces between end-effectors 90% of payload of weakest
9.6 Relative positioning precision 2% of intersecting workspace scale
9.7 Relative positioning precision 1% of intersecting workspace scale
9.8 Relative positioning precision 0.1% of intersecting workspace scale
9.9 Relative positioning precision 0.01% of intersecting workspace scale

10. DISTURBANCE REJECTION FROM THE PROCESS

10.0 Sinusoidal force at end-effector of 1% of payload (n=10)
10.1 Sinusoidal force at end-effector of 5% of payload (n=3)
10.2 Sinusoidal force at end-effector of 25% of payload (n=2
10.3 Sinusoidal force at end-effector of 50% of payload (n=1)
10.4 Random force disturbance at end-effector of 1% of payload
10.5 Random force disturbance at end-effector of 5% of payload
10.6 Random force disturbance at end-effector of 25% of payload
10.7 Random force disturbance at end-effector of 50% of payload
10.8 Sudden shock of 10% of payload
10.9 Sudden shock plus random force disturbance

Sinusoidal - $\omega >$ nx time scale