IN-GRASP TRANSLATION PROTOCOL

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Purpose	To assess the robot or human hand's in-grasp translation capability and the size of achievable workspace. The protocol determines the hand's or gripper's ability through sensorized object translation.
Task Description	A chosen sensorized object is periodically displaced between maximum achievable offsets in x, y and z axes of the assessed hand, while maintaining fingertip contact with the object.
Setup Description	**List of objects and their descriptions:** The cylinder, cube, and sphere from the modular, sensorized object collection, equipped with appropriate motion capture markers/sensors, are used in the protocol.
	Initial and target poses of the objects: The objects are initially grasped by the examined hand and are entirely supported by its fingers. The initial pose is hand-specific, but it must be the same for all trials and objects (position and orientation, with respect to the hand base frame).
	Description of the manipulation environment: If using optical motion capture equipment, the space should be free of clutter and reflective surfaces. If using magnetic motion capture equipment, the environment should be free of large metallic objects or magnetic fields (excluding the hand).
Robot/Hardware/Software/Subject Description	**Targeted robots/hardware/software:** Any hand or gripper capable of open- or closed-loop in-hand manipulation (translation) may be used in the protocol. There are no constraints on the control software - a package that maximizes performance should be used.
	Initial state of the robot/hardware/subject with respect to the setup: The assessed robot hand or gripper may be fixed on a rigid surface. If a human hand is examined, the forearm should rest on a rigid surface with the palm facing up.
	Prior information provided to the robot (if applicable): Prior to the manipulation operation, the robot hand should be programmed and tested with the object in order to achieve maximum possible offset and performance. The robot does not need to know the object model or properties.
Procedure	Repeat following steps for each object in the x, y and z axis with respect to the assessed hand base frame: 1) Position the object into the assessed hand, so it remains grasped in the defined initial position. 2) Begin object motion data recording with the chosen motion capture system. 3) Run the system. The object should be displaced between the minimum and maximum offset in the assessed axis 10 times in a single run. During manipulation, the object does not need to move only in the assessed axis. 4) Stop the system and motion recording.
Execution Constraints	The object offsets must be achieved through in-hand manipulation: the hand base frame must remain static during the task execution. During manipulation, the object must be supported entirely by the hand fingers. The object does not need to move only in the examined axis - single, compound manipulation motion may be used for obtaining results in multiple axes. However, the maximum number of compound motions is still limited to three. The assessed hand must maintain fingertip contact with the object during manipulation.
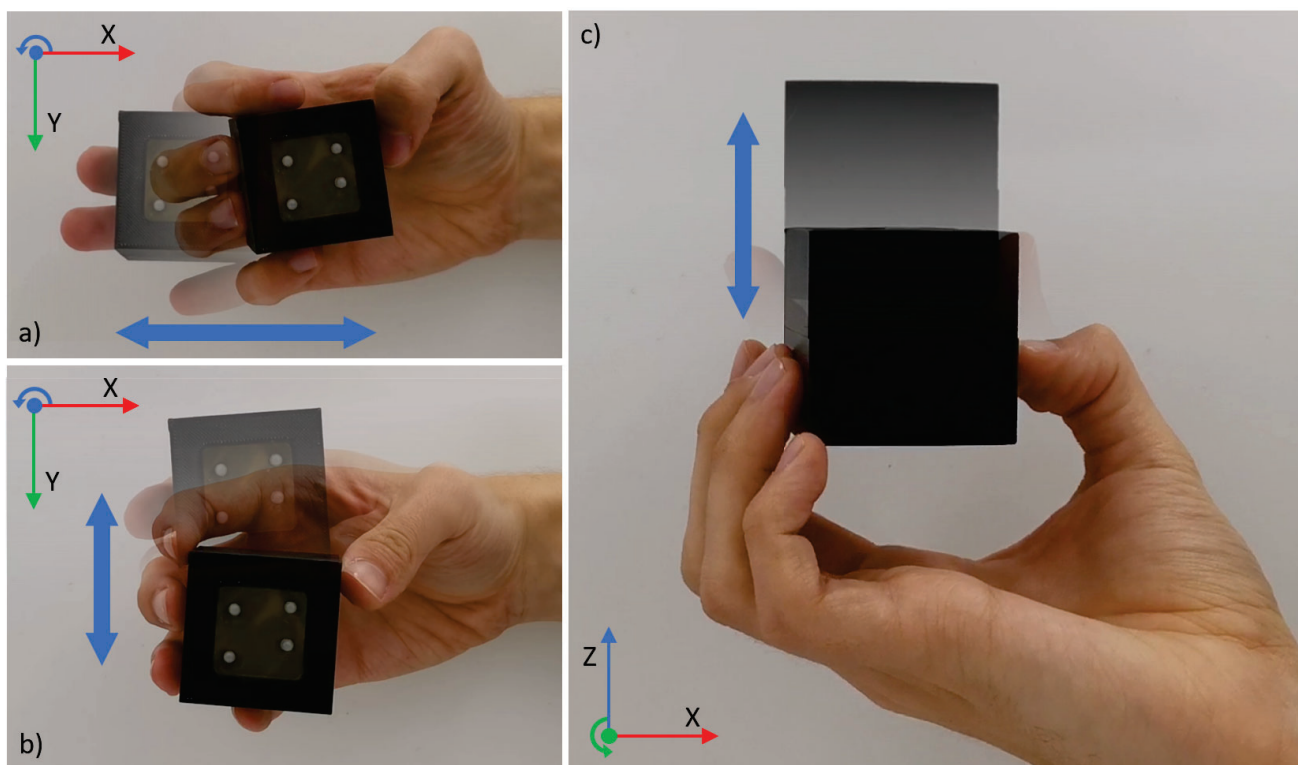
Fig. 1. In-hand translation protocol goal motions. The aim of the protocol is to assess the manipulator's ability to move an object along the X axis (subfigure a), Y axis (subfigure b), and Z axis (subfigure c).