James Watt Institute *for* High Value Manufacturing

Complaint Parallel Manipulators and Disassembly-free Reconfigurable Parallel Manipulators

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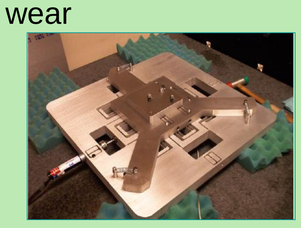
Compliant Parallel Manipulators

Characteristics

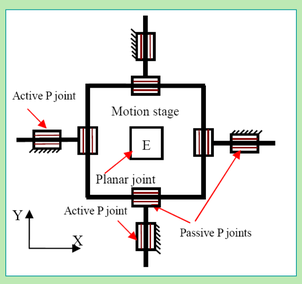
- Motion and force transmission through deformation of links
- No drawbacks such as backlash, lubrication and wear
- High accuracy
- Approximate decoupling
- Constrained parasitic motion
- Large range of motion with minimal lost motion and maximal actuation isolation



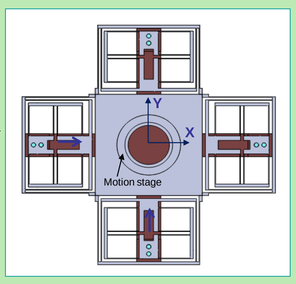
Planar XY decoupled CPM
(Courtesy of Prof S. Awtar, University Michigan, USA)

Applications

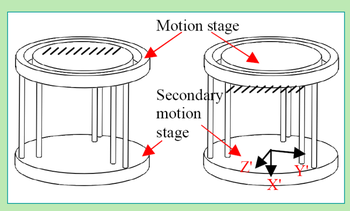
- Micro/nano-manipulation and micro-assembly
- Scanning table and bio-cell injector



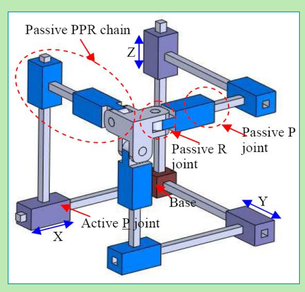
4-PP-E XY conventional parallel manipulator



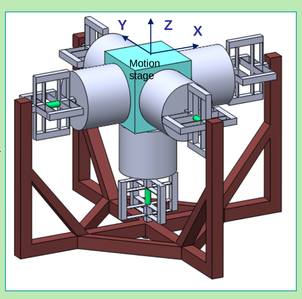
Large range stiffness-enhanced XY CPM



Spatial double three-beam modules (E joint)



3-PPPR XYZ conventional parallel manipulator



Large range XYZ CPM

Figure 1 Large range XY and XYZ compliant parallel manipulators (CPMs).

About the novel XY CPM

- Motion range: 4mm × 4mm
- Input(force)-output(displacement) decoupled
- Lost motion: 0.19%
- Parasitic translational displacement: <0.008mm.
- Parasitic rotational angles: <20urads

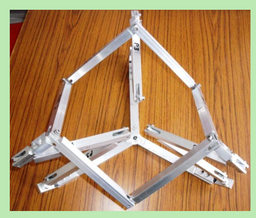
About the novel XYZ CPM

- Motion range: 5mm × 5mm × 5mm
- Input(force)-output (displacement) decoupled
- Lost motion along X/Y-axis: 0.44%
- Lost motion along Z-axis: 0.20%
- Parasitic rotational angles about X/Y-axis: $<1.6\times10^{-4}$urads
- Parasitic rotational angles about Z-axis: $<10^{-6}$urads

Reconfigurable Parallel Manipulators

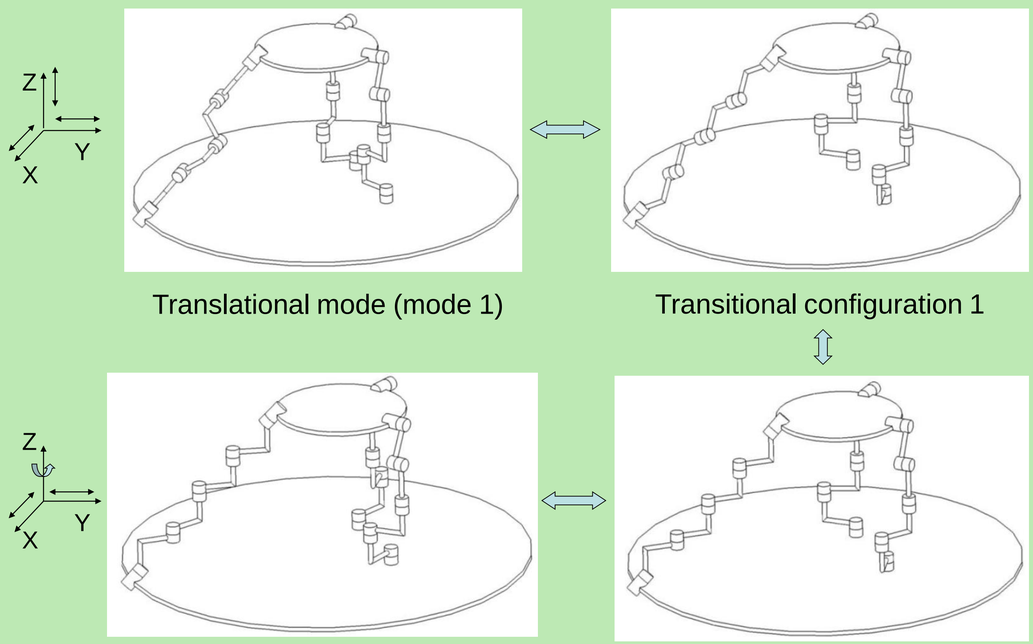
Characteristics

- Multiple operation modes like two or more conventional parallel manipulators
- Adaptive to variable tasks and environment
- Reconfigurable without disassembly
- Fewer actuators needed
- Reduced cost
- Simplified control



Applications

- Assembly robots
- Machine tools
- Modules of self-assembling robots
- Multi-functional products



Translational mode (mode 1) — Transitional configuration 1

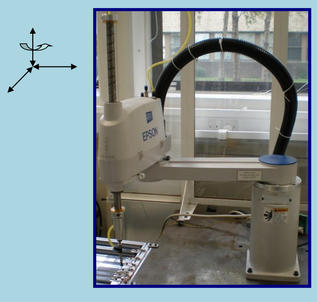
Planar mode (mode 2) — Transitional configuration 2

Figure 2 Transition of a 3-degrees-of-freedom disassembly-free reconfigurable parallel manipulator from translational mode to planar mode

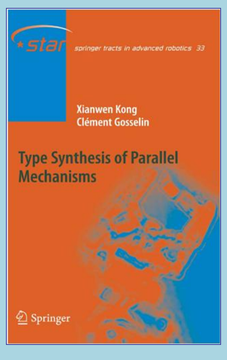
* For details, see
Kong, X., Proceedings of ASME 2011 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference, Paper number DETC2011-48510, Washington, USA, August 28-31, 2011.

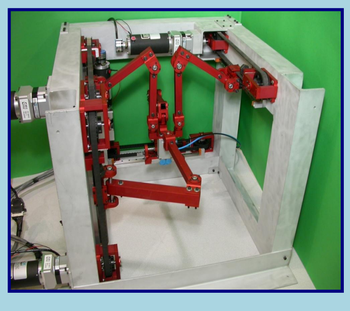
***** Supported by **EPSRC** through project EP/I016333/1 “Creative Design of Parallel Manipulators with Multiple Operation Modes”.

Conventional Parallel Manipulators



SCARA (serial) manipulator





Based on Kong and Gosselin, U.S. patent 2006
(Courtesy of Prof C Gosselin, Laval University, Canada)

Characteristics

- Actuators located on or close to the base
- High payload/weight ratio
- High accuracy
- High velocity
- A small workspace/footprint ratio

Applications

- Assembly manipulators
- Parallel kinematic machines (machine tools)
- Haptic devices
- Coordinate Measuring Machines (CMMs)
- Biomedical devices

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