

# Hybrid Serial-Parallel Linkage Based six degrees of freedom Advanced robotic manipulator

Mr. Umakant Dinkar Butkar, Manisha J Waghmare

Sir Visvesvaraya Institute of Technology, Nashik, India.

Matoshri College of Engineering & Research Centre

## Abstract:

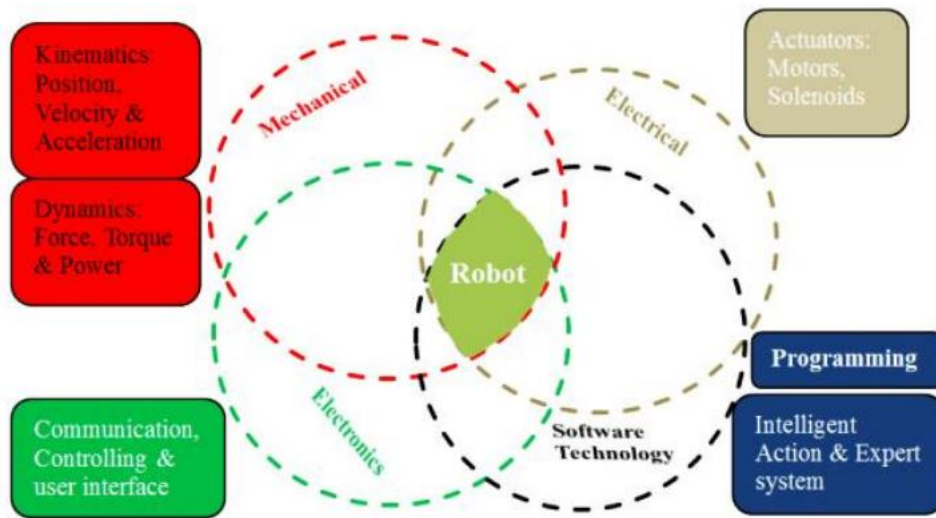
There is a hybrid robotic manipulator that can move items available. A base with a waist mounted on it and set up to spin on the base makes up the hybrid manipulator. A pair of arms positioned on the waist is another feature of the hybrid manipulator. Each arm consists of an upper arm, a forearm connected in series to the upper arm at the elbow, and a wrist designed to join the two arms at their distal ends using two connecting parts. The wrist also has an end-effector installed on it that can grab the object and move it to the correct position. A hybrid manipulator is created by combining serial and parallel manipulator systems in a beneficial way. It combines the beneficial performance traits of a parallel manipulator and a serial manipulator. A 3 DOF symmetric planar manipulator serves as the foundation of the hybrid manipulator under research, which was then put over a 3 DOF serial manipulator with the necessary end effector.

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## 1. Introduction

New technologies are created to meet the growing demand for goods and services. Robots are gaining ground in production and service operations thanks to their adaptability, automation, and lower cost compared to specialized machinery [1-8]. These benefits have encouraged the study and creation of such robots. Figure 1 illustrates how the design of a robot, a multidisciplinary engineering device [9-12]. The kinematics, dynamics, and structural requirements of the robot are covered in the mechanical portion. The actuators that produce the primary motion in the robots' joints are the focus of the electrical section [13-18]. Robot perception, sensing, and control are all covered by system design. The software technology incorporates algorithm and intelligence into the robot, allowing it to operate independently or under the guidance of a professional.

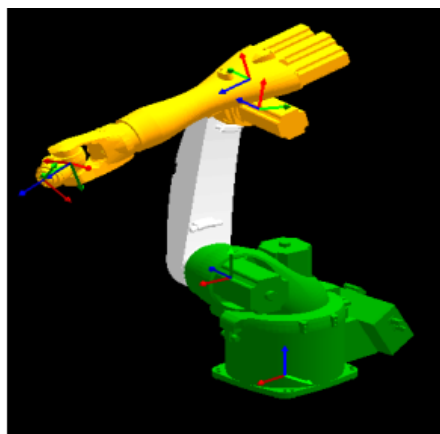


Robotics is multidisciplinary, as shown in Figure 1.

The three main categories of manipulators are determined by the kinematic structure:

- [i] Serial robots or open loop manipulators
- [ii] Parallel Robots or Closed Loop Manipulators
- [iii] Hybrid manipulator (figure 4)

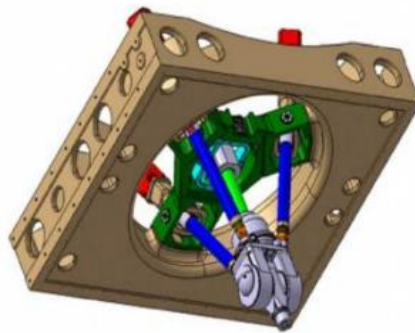
Figure 2 depicts a KUKA 650 Industrial Manipulator, a serial robot with six DOF. An example of a parallel robot with six degrees of freedom is shown in Figure 3. An illustration of a serial parallel hybrid robot with 6 DOF is shown in Figure 4.



Robot KUKA 650 in Figure 2.



ABB Delta Robot in Figure 3.



Serial Parallel Robot (Figure 4)

In comparison to parallel robots, the serial manipulator has a bigger workspace and greater dexterity, but it lacks stiffness and positional accuracy[19-26]. While parallel manipulators are stiffer and lighter, they are not appropriate for vast work spaces due to their constrained workspace and complicated kinematics[27-33]. The advantages of both parallel and serial robotics are combined in hybrid manipulators. Hybrid robotic manipulators, may be built by combining the two types of manipulators. As a result, a hybrid manipulator emerges as a plausible contender to carry out a variety of tasks related to complex geometries[34-40].

## 2. Reading Survey

The design, manipulation, and performance features of a hybrid manipulator have been researched in a variety of study areas. The serial, parallel, and hybrid configurations were each referenced to and analyzed independently in order to discuss the current design.

## 2.1 Serial Manipulator

Industrial manipulators were developed to lessen the laborious and repetitive tasks that required human labor. Links and kinematic joints make up the manipulation system to offer a degree of freedom. Mechanism theories propose a synthesis of spatial and planar mechanisms with numerous degrees of freedom. Cubero outlines a design method to the examination of the kinematic chain of an industrial manipulator. The technique produces flat mechanical structures with various degrees of freedom. Singh et al.'s computer technique for resolving robot kinematics using differential transformation matrix theory and D-H Parameters. For the inverse translation of the coordinates (analytical) kinematics of robotic manipulators, Pashkevich created methods. The found solutions have good convergence, including sites for singularities. Dynamic algorithms and inverse kinematics were also covered in. In this instance, the joint actuation (torques and forces) is used to operate the robot and create the end effector trajectory. As the number of linkages rises, so does the complexity of inverse kinematics.

## 2.2 Parallel Manipulator

Based on screw theory, Hunt investigated the kinematics of parallel manipulators. The workspace for existing parallel manipulators is constrained, complex, contains singularities, and has very non-isotropic input/output relations. As a result, depending on the workspace and the motion's direction, performances may vary greatly. A 3R symmetric planar platform has a non-singular assembly mode shifting trajectory, according to Chablat and Wenger's inverse kinematic solution. Do and Yang solved the inverse dynamics of a parallel platform using the Newton-Euler method while assuming asymmetrical legs and frictionless joints. One planar parallel manipulator is the subject of kinematic studies by Shirkhodaie and Soni, Gosselin and Angeles, Pennock and Kassner, and Gosselin and Angeles. A general calculation approach for the dynamics and kinematics of parallel or planar robots is presented by Gosselin et al. in their paper from page 24.

**2.3 S-P Hybrid Manipulator** – Study of Architecture Multiple topologies that combine closed and open loop links use hybrid manipulators. This section presents a few inventive hybrid architecture implementations that are appropriate for various applications. This will give you more knowledge about hybrid manipulators, their potential uses in the present and the future. Through linear driving and simple control, six DOF motion is made possible and could be used in surface manufacturing. For tackling precise tasks, an unique dexterous 6DOF manipulator coupled serially by two compliant parallel stages is described. Three-RPS and three-

RRR mechanisms are used in the higher and lower stages, respectively. Optimal design has been attained thanks to the physical model of the solution space technique.

Ota et al. introduced a six-legged robot that walks by moving each leg base alternately through a six degrees of freedom mechanism. The robot has two leg bases and three legs. It was discovered that adopting a hybrid mechanism might result in high performance after comparing the force, velocity, and moveable range of different mechanisms for connecting the two legs bases.

**2.4 S-P Hybrid Manipulator** – Kinematics Research Forward and inverse kinematics need to be researched in order to construct and model a hybrid manipulator. The kinematic and dynamic study of a 10 DOF hybrid manipulator was examined by Waldron et al. For FK but not IK, a closed form polynomial solution was obtained. By using rate kinematics analysis, Lee and Kim established a projection approach for the kinematic study of a 6 DOF hybrid manipulator. However, there was no discussion of the FK and IK displacement analysis. Shukla and Paul introduced the idea of a "virtual link," where the hybrid manipulator can be thought of as an equivalent serial link and the parallel structure as a virtual link. However, kinematic models are challenging to develop. In order to create a hybrid robot for deburring applications, Yang et al. described a modular strategy and produced closed form kinematic solutions that were confirmed through simulations. The created prototype uses an RPR serial arm and end effector as well as a 3RRR planar manipulator as its base.

### 3. Summary

Depending on the design goal and performance, hybrid manipulators could combine serial and parallel setups. The following two variations are the most workable answers to this issue, which calls for a modular reconfigurable manipulator with generalized operability for this project.

Type I: To create a hybrid serial and parallel mechanism, a 3 DOF planar parallel manipulator might be fixed to this configuration, together with a 3 DOF serial manipulator. (Figure 6).

Type II: In this arrangement, a platform is supported by three serial arms. The platform has six degrees of freedom overall thanks to the serial arms' two active joints and four passive joints. In Figure 7,

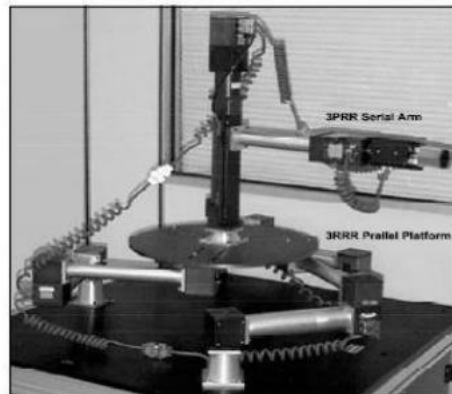


Figure 6: Type I Configuration Example

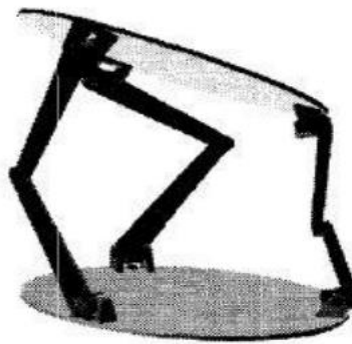


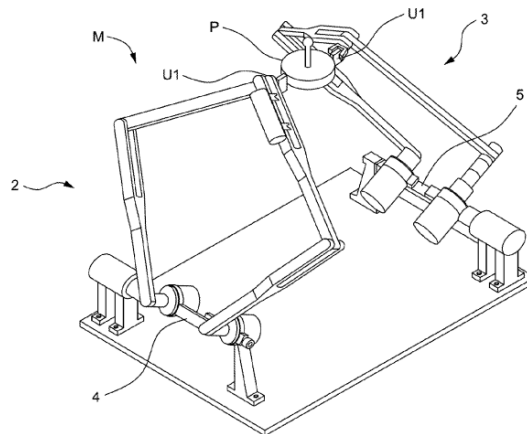
Figure 7: A Type II configuration example

To employ any of the aforementioned mechanisms, it is necessary to optimize factors like stiffness, workspace range, weight balances, link collision event, and actuator location. The best distribution of mass and space between the two configurations is for the manipulator configuration chosen in this project. Additionally, fewer linkages should be used to create a machine that is lighter and less prone to linkage collisions. The Type I manipulator offers a better trade-off than the later because to its lower center of gravity, higher structural rigidity, and computationally simpler inverse kinematics after careful analysis of performance characteristics and kinematic complexity. A three DOF parallel manipulator serves as the basis support for the proposed hybrid manipulator, which also includes a three RRR articulated serial arm fixed with a desired end effector. The serial arm could have a simpler design because the parallel base provides three degrees of freedom (planar). This manipulator could deliver the needed performance. This strategy is beneficial for

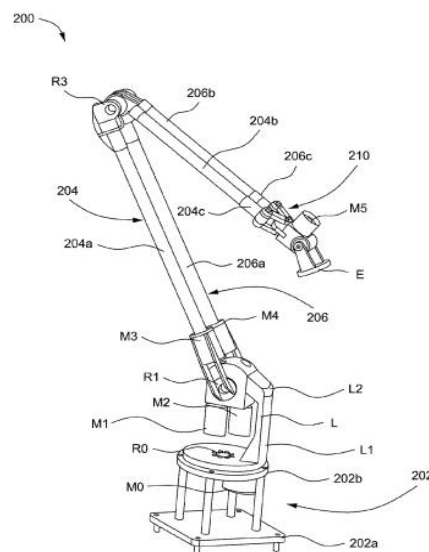
- Design updates and alterations at any project stage.
- Reduce the time needed for design or construction.

- Modify the joint types, actuation strategies, and link lengths.

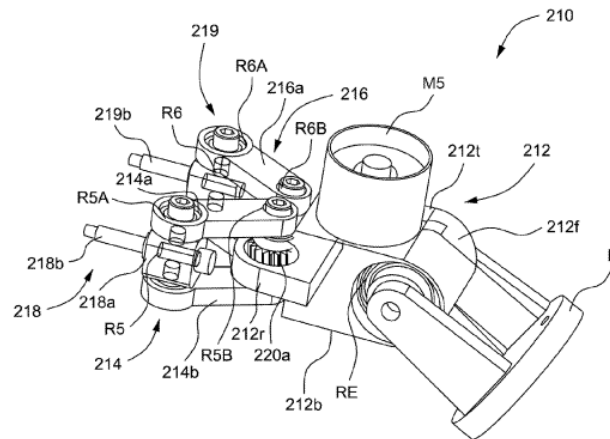
#### 4. DESCRIPTION OF A SIX DEGREES OF FREEDOM HYBRID SERIAL-PARALLEL LINKAGE BASED ROBOTIC MANIPULATOR



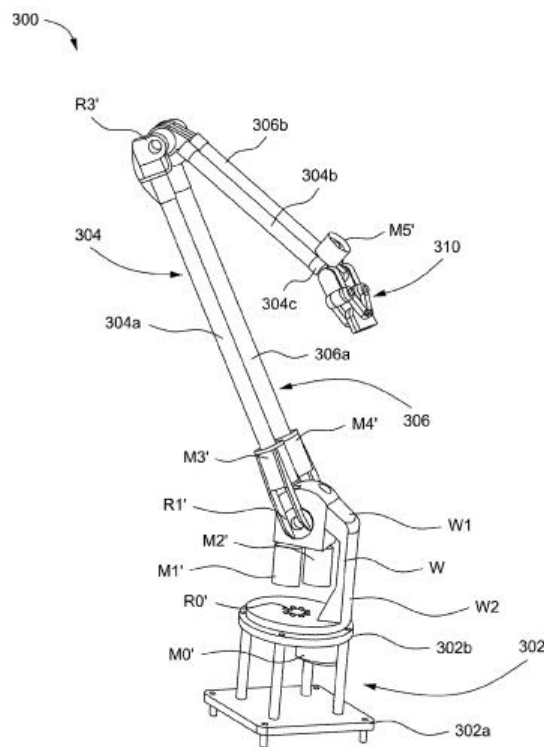
A robotic manipulator is depicted in FIG. 8 according to information found in related art.



A hybrid robotic manipulator that complies with one of the above described embodiments is shown in FIG. 9.



The hybrid robotic manipulator shown in FIG. 9A's wrist section is displayed.



Another example of a hybrid robotic manipulator is shown in FIG. 10.



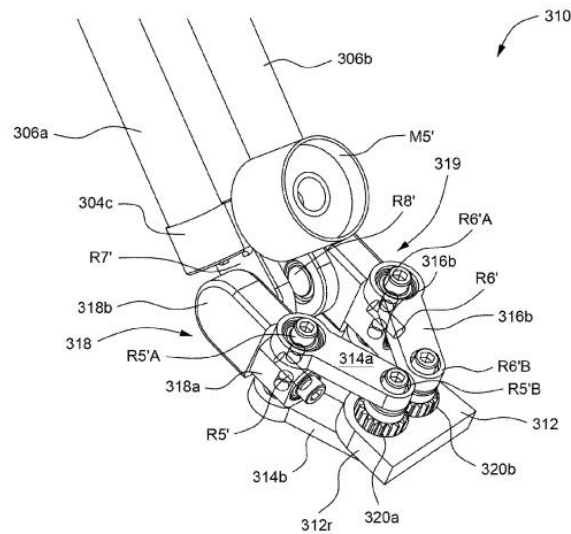


FIG. 10A shows the wrist portion of the hybrid robotic manipulator.

#### 4.1 THE TECHNOLOGY FIELD

This invention relates to robots that can manipulate objects, more particularly, but not exclusively, hybrid robots that do so by combining serial and parallel linkage systems.

#### 4.2 READING IN SUMMARY

The major objective is to build a hybrid robotic manipulator that makes advantage of both parallel and serial communication techniques. Another objective is to develop a hybrid robotic manipulator with a workspace for position comparable to a serial link manipulator and a workspace for orientation akin to the human wrist. Another objective is to develop a hybrid robotic manipulator that can employ smaller, less expensive motors to move its linkages because most of its actuators are located closer to the robot's base.

#### 4.3 DESCRIPTION OF FIGURE IN SUMMARY

As like reference letters/numbers indicate corresponding areas in the various figures, the preceding drawings illustrate this idea. You can better comprehend the embodiments described here by reading the following description with reference to the figures: A robotic manipulator is shown in FIG. 8 according to the related art; a hybrid robotic manipulator is shown in FIG. 9 according to an embodiment disclosed here; a wrist portion of the hybrid robotic manipulator is shown in FIG. 9A; a hybrid robotic manipulator is shown in FIG. 10 according to another embodiment; and a wrist portion of the hybrid robotic manipulator is shown in FIG. 10A;

#### 4. Conclusion

In this study, a brand-new type of hybrid serial-parallel mechanism is introduced, one that combines a pure 3-UPU translational mechanism with a pure 3-UPU spherical rotation mechanism. For real-time applications, this type of serial-parallel mechanism is simple to regulate and can have its motion simplified to pure translation and pure spherical rotation. This hybrid mechanism was initially proposed as a compensating platform in a deep-sea mining system to take into account a ship's heave, rolling, and pitching. The closed-form solution for the direct position problem for the two types of 3-UPU mechanism is shown together with a comprehensive numerical demonstration based on the proposed technique.

#### Conflict of interest:

There is no conflict of interest.

#### Data availability statement:

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

#### Funding Statement:

This study did not receive any funding in any form.

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