

## Development, analysis and optimization of the performance of an innovative driving simulator

### Kinematic analysis

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The kinematic analysis...

## 1 Kinematic equations

In this section the mechanism's behaviour is studied. In Figure 1 is shown the top view of the mechanism.

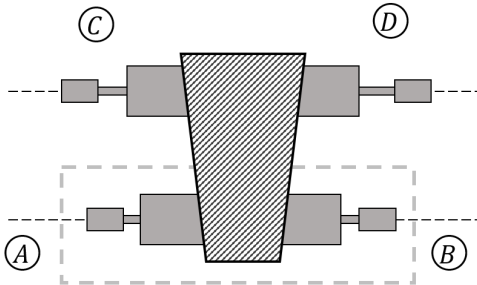


Figure 1: Top view of the full-mechanism.

In first approximation a 2D analysis is conducted, and is referred only to the bodies (A) and (B).

### 1.1 2D-kinematic analysis

The mechanism studied in the 2D simplification is the marked part in Figure 1, in fact only bodies (A) and (B) are taken into account, and the result is shown in Figure 2.

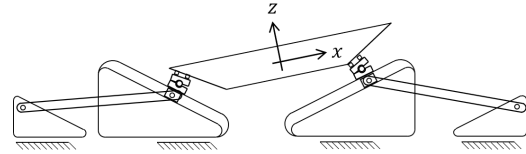


Figure 2: 2D mechanism.

For the 2D analysis it is chosen to consider the length of the platform as a constant, even if it could be variable, due to its geometry. More complex analysis are made in the following Section 1.2 during the 3D analysis.

Thanks to this consideration it is possible to say that the full-mechanism is composed by two mirrored sub-mechanisms, made by four sub-bodies, joined by the platform. So the sub-mechanism studied is shown in Figure 3. The same can be done for all the other sub-mechanisms by changing the subscripts.

At a first sight, it is easy to say that the four motors will be the independent variables, they



as already said, supposing a constant value of the length of the platform, one can be considered as “dummy”). In that section, not all the velocity ratios were plotted but only the ones related to the X and Y position of the end effector and to its roll angle because those one were the only one really significative for our analysis. Speaking about that section, a procedure for the plots called *velocity-plot* was made. More specifically the procedure takes as inputs:

- *EE\_number*: chosen number between 1 and 3 that identifies the correct end effector variable (X, Y or angle);
- *actuator\_number*: desired actuator variable w.r.t whom we choose to plot the solution;
- *actuator\_extremes*: two elements vector that identifies the extreme positions of the desired actuator;
- *constant\_actuators\_values*: two values vector that identifies the values to be assigned by the two actuators that remain constant.

and gives as outputs the trasmission ratios between X, Y position and angle of the end effector and the actuators as a function of one of the three independent DoF, assuming the other two as constants. As third main point it was decided to plot, besides the velocity ratios, also the pure velocities of the X, Y position of the end effector and its roll angle w.r.t. the position of one of the three DoF. In that case, as the requests specified, the velocity of the active actuator was fixed to one while the position of the other two actuators was maintained in the initial position. In order to develop this part, at first, it was calculated analitically the velocity of the dependent coordinates solving the derivative w.r.t. time of the equation of the complete set of constraints considering as unknowns the derivative w.r.t. time of the complete set of dependent coordinates. Then, in the solution obtained, was substituted the chosen solution of the kinematics found before.

### 3 Acceleration analysis

Regarding the acceleration analysis, this part was quite similar to the one made before. As a matter of fact, having the analitical solution of the kinematics, in order to obtain the expression of the acceleration of the dependent coordinates it was solved the double derivative w.r.t. time of the complete set of constraints considering as unknowns the double derivative w.r.t. time of the complete set of dependent coordinates. After that, the chosen solution of the kinematics was substituted into the expression of the dependent acceleration in order to obtain them as dependent only to the independent variables. Moreover the acceleration of the X, Y coordinates and of the roll angle of the end effector was plotted w.r.t the position of each one of the three DoF (maintaining the other two fixed at each time). Furthermore, as the the requests specified, the velocity and the acceleration of the moving actuator, that was considered for each plot, were fixed to an unitaty value.

### 4 Effects of the main geometrical parameters

## References

- [1] “*Advanced Vehicle Driving Simulator*”, ABDYNAMICS.
- [2] “*6DOF Motion System*”, CKAS.
- [3] M. Kasim A. J., “*Design and development of 6-dof motion platform for vehicle driving simulator*”, Universiti Teknologi Malaysia.