

Software Lab Computational Engineering Science

Group 12, Pusher Mechanism

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Informatik 12: Software and Tools for Computational Engineering (STCE)
RWTH Aachen University

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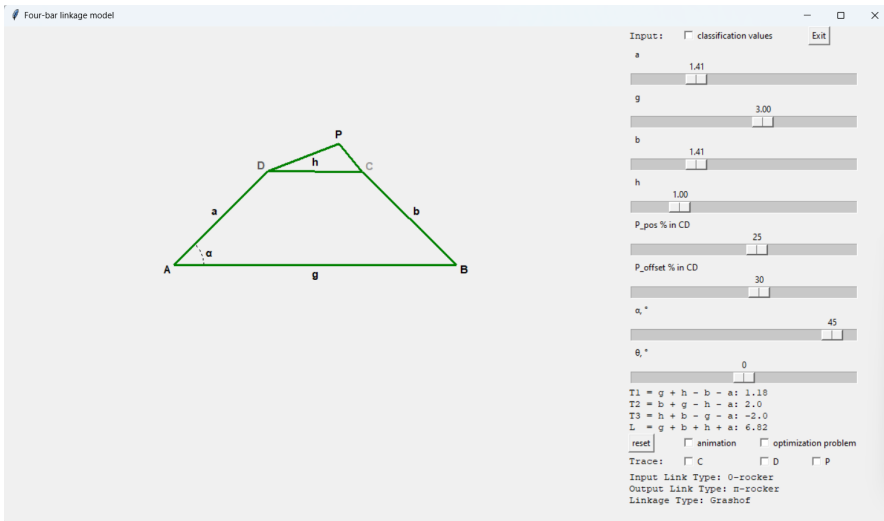
- 27 movement types

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Summary and Conclusion



- Implement 27 motion types of the four-bar linkage with one bar fixed:

- Classification values:

- $T_1 = g + h - b - a$

- $T_2 = b + g - h - a$

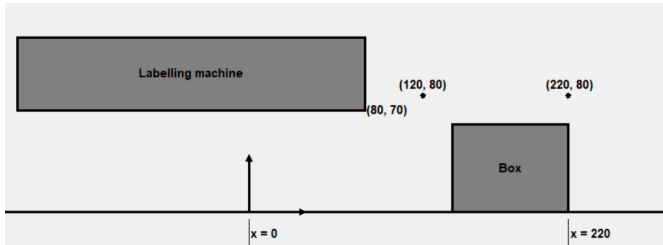
- $T_3 = h + b - g - a$

- Implement GUI with motion animation and the ability to choose geometrical parameters:

- Length of the bars
- Position of the coupler
- Input angle
- Angle relative to the horizon
- Classification values as alternative input

No.	T_1	T_2	T_3	$T_1 T_2$	$T_1 T_3$	a	b
1	+	+	+	+	+	crank	rocker
2	0	+	+	0	0	crank	π -rocker
3	-	+	+	-	-	π -rocker	π -rocker
4	+	0	+	0	+	crank	0-rocker
5	0	0	+	0	0	crank	crank
6	-	0	+	0	-	crank	crank
7	+	-	+	-	+	π -rocker	0-rocker
8	0	-	+	0	0	crank	crank
9	-	-	+	+	-	crank	crank
10	+	+	0	+	0	crank	π -rocker
11	0	+	0	0	0	crank	π -rocker
12	-	+	0	-	0	π -rocker	π -rocker
13	+	0	0	0	0	crank	crank
14	0	0	0	0	0	crank	crank
15	-	0	0	0	0	crank	crank
16	+	-	0	-	0	π -rocker	crank
17	0	-	0	0	0	crank	crank
18	-	-	0	+	0	crank	crank
19	+	+	-	+	-	0-rocker	π -rocker
20	0	+	-	0	0	0-rocker	π -rocker
21	-	+	-	-	+	rocker	rocker
22	+	0	-	0	-	0-rocker	crank
23	0	0	-	0	0	0-rocker	crank
24	-	0	-	0	+	0-rocker	0-rocker
25	+	-	-	-	-	rocker	crank
26	0	-	-	0	0	0-rocker	crank
27	-	-	-	+	+	0-rocker	0-rocker

Figure from "Classification, geometrical and kinematic analysis of four-bar linkages" 10.15308/Sinteza-2018-261-266 by Ivana Cvetkovic et al.



- ▶ Solve an optimization problem:
 - ▶ Push box with size 80×60 from $x = 220$ to $x = 0$
 - ▶ Do not cross the area of the labelling machine (Area with $x < 80$ and $y > 70$).
 - ▶ Pass above points $(120, 80)$ and $(220, 80)$

▶ **Four-bar linkage model:**

- ▶ System simulates all the motion types of the four-bar linkage.
- ▶ System does not crash with any input of geometrical configuration.

▶ **Tests:**

- ▶ Implement test cases for geometry.
- ▶ Implement test cases with bad input to test system stability.

▶ **Graphical User Interface:**

- ▶ GUI provides the four-bar linkage visualization and motion animation.
- ▶ User can input geometrical data by moving a point on a slide bar.
- ▶ GUI is coupled with the four-bar linkage model to use implemented motion cases for animation.
- ▶ GUI provides tracing for trajectories of the points.
- ▶ GUI classifies of the linkage.

▶ **Optimization problem:**

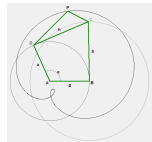
- ▶ It should be possible to find a solution (manually) for the optimization problem using the four-bar linkage model.
- ▶ GUI visualizes the solution.

► **Performance:**

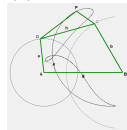
- The four-bar linkage model is fast enough to provide smooth GUI animations.
- GUI animations are not slower than 30 frames per second.

► **Usability:**

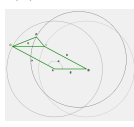
- Every essential part of the four-bar linkage model is well documented.
- GUI is easy to operate and all functionalities are self-explanatory.
- GUI source code is well documented.



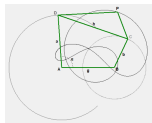
$$T_{1,2,3} = 0.0, 0.0, 1.0$$



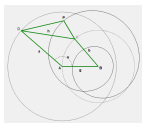
$$T_{1,2,3} = 1.0, 1.0, 0.0$$



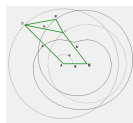
$$T_{1,2,3} = -1.0, 0.0, 0.0$$



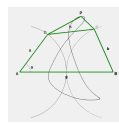
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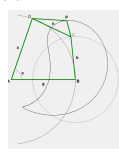
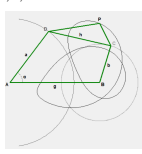
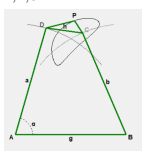
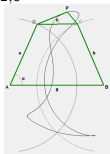
$$T_{1,2,3} = 0.0, -1.0, 0.0$$



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$$T_{1,2,3} = 1.0, 1.0, -1.0$$

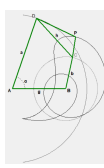
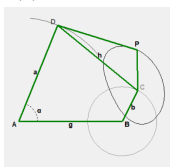


$$T_{1,2,3} = 0.0, 1.0, -1.0$$

$$T_{1,2,3} = -1.0, 1.0, -1.0$$

$$T_{1,2,3} = 1.0, 0.0, -1.0$$

$$T_{1,2,3} = 0.0, 0.0, -1.0$$

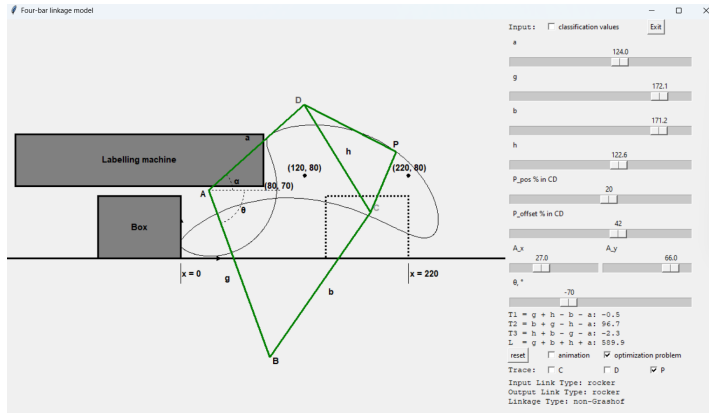


$$T_{1,2,3} = -1.0, 0.0, -1.0$$

$$T_{1,2,3} = 1.0, -1.0, -1.0$$

$$T_{1,2,3} = 0.0, -1.0, -1.0$$

$$T_{1,2,3} = -1.0, -1.0, -1.0$$



- ▶ 9 degrees of freedom (all lengths in cm):
 - ▶ Length of four bars: $a = 124.0$, $b = 171.2$, $g = 172.1$, $h = 122.6$.
 - ▶ Coupler position: $P_{pos} = 20.0\%$, $P_{offset} = 42.0\%$ of h .
 - ▶ Position of point A: $A_x = 27.0$, $A_y = 66.0$.
 - ▶ Angle of ground bar relative to horizon: $\theta = -70.0^\circ$

Summary and Conclusion

- ▶ Cvetkovic, Ivana and Stojicevic, Misa and Popkonstantinović, Branislav and Cvetković, Dragan. (2018). Classification, geometrical and kinematic analysis of four-bar linkages. 261-266. 10.15308/Sinteza-2018-261-266.