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AN ENHANCED GRAPHICAL SYSTEM FOR CREATION AND ANIMATION OF PLANAR MECHANISMS

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AN ENHANCED GRAPHICAL SYSTEM FOR CREATION AND ANIMATION OF PLANAR MECHANISMS

By

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ABSTRACT

AN ENHANCED GRAPHICAL SYSTEM FOR CREATION AND ANIMATION OF PLANAR MECHANISMS

By

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The objective of this project is to create an environment where the mechanism components such as links, joints, and springs can be created individually and assembled together using a graphical terminal similar to assemblage of the actual parts. To implement this idea, an Evans and Sutherland PS 300 graphical terminal is used to define and display two dimensional pictures of the links. Then, the links are moved to the desired locations and are connected by either sliding joints or pin joints. In the creation phase, any planar mechanism with lower pairs with any degrees of freedom and any number of links, joints or loops can be constructed. The generated input data are processed by MAP (an automated procedure for analysis of mechanisms) to animate the motion of the mechanisms. The system also has the capability of drawing the trace of any point on any link specified by the user.

To my parents

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CHAPTER I

INTRODUCTION

The application of the computer to the processes of design and production was widely perceived as leading to fundamental changes not only in accuracy and speed but also in the entire structure of these processes. Among these changes were the automation of intellectual labor and a change from paper-based to computer-based information systems wherein the user interacted with the flow of processing and maintained control by the selection of data.

The purpose of this project is to use a graphic terminal to draw a mechanism, analyze it, and display the results. All the processes are done interactively through a computer.

The softwares include a preprocessor, an automated mechanism analysis program, MAP[1,2], and a postprocessor. MAP has been developed at Purdue University by Behrooz Fallahi under the supervision of Dr. Ragsdell. The two other softwares, the preprocessor and postprocessor, are the byproduct of this project.

The preprocessor enables one to define the mechanism components graphically such as links, joints, and springs. The generated components can be relocated and assembled together. These procedures are used as inputs to MAP for further analysis. The postprocessor uses the output of MAP to animate the motion of the mechanism and to display other information of interest to a designer such as the trace of a point on a link.

1.1 Review of Mechanism Analysis Methods

In the following, a review is presented of the papers that show the trends in the analysis of mechanisms.

Analytical methods based on vector and complex number methods were developed as an alternative to graphical methods. The nonlinearities in the governing equations have been an impediment to obtaining the solution. The development of iterative methods and the availability of the computer as a problem solving tool gave rise to the development of efficient methods for solving mechanism problems. The general applicability of iterative methods becomes the seed for the development of unified methods for mechanism analysis, unified in the sense that the steps in the thought process are the same in formulating the governing equations for different mechanisms. The best examples in this class are the work of Chace[3,4,5] and Uicker[6,7].

The next generation of techniques for mechanism analysis is that of automated procedures where the user need only to specify the physical description of the mechanism and the computer forms and solves the governing equations of motion. This automation has become possible through the introduction of topological analysis and data structure to the unified methods. The data structure provides a unified means for the description of the mechanism and the topological analysis provide a unified means for generating the sequence of instructions to form the governing equation of motion. Some examples of programs based on automated procedures are: KAM[8], MEDUSA[9], DYMAC[10,11], VECNET[12,13], DRAM[14,15], DAD[16], ADAMS[17,18], IMP[19], and MAP[1,2].

The degrees of automation for the procedures listed above are different. For example solving a problem using MEDUSA[9] requires calling a sequence of standard routines which are built in MEDUSA. For DYMAC the user describes not only the dimensions and positions of the links, but also the set of independent loops and the paths to the mass centers of the links. DRAM, DAD, ADAMS, IMP and MAP are fully automated in the sense that physical descriptions of the mechanisms are required.

Recently, researchers have started to develop graphical interfaces for mechanism analysis programs[20,21]. These graphical interfaces enable the user to define the mechanism and display the analysis results and animate the motion of the mechanism through easy interaction with computer.

CHAPTER II

A DATA STRUCTURE FOR MECHANISMS

In order to analyze a mechanism, the mechanism created on the graphic terminal must translate into numerical data which can be understood by the program. So, a data structure introduced below is the numerical information for the description of kinematic chains and being used by MAP. It is classfied into four categories. In each case a definition and a form for the representation is discussed.

2.1 Connectivity Data

Connectivity is defined as the information necessary to determine which link is connected to which joint. Since two links are connected through one joint, the two links are differentiated by being a Beginning Link or an End Link. To represent the connectivity data, two one-dimensional arrays, the Beginning Branch Vector (BBV) and the End Branch Vector (EBV) are introduced. The BBV contains the Beginning Link numbers. Similary, the EBV contains the End Link numbers. The BBV and EBV for the quick-return mechanism of Figure 2.1 are

BBV = [1,1,2,3,3,1,5]

EBV = [2,3,4,4,5,6,6]

2.2 Design Data

Design data referred to in this work provide the information needed for positioning the joints on the links.

Positioning a pin joint or a sliding joint translates into positioning two points or two lines whose coincidence characterizes a pin joint or a sliding joint, respectively. A point or a line can be located by a R-vector (see Figure 2.2) which is further classified as a R^--vector or a R^+-vector depending on whether it is on a Beginning Link or an End Link.

The design data are then defined as four arrays containing the length of the R^+-vectors and R^--vectors and their angles with respect to the reference unit vectors of their attached links. Figure 2.3 shows the six bar quick-return mechanism with reference point (P), reference unit vector (u), and R^+-vectors and R^--vectors. The design data for the six bar quick-return mechanism are shown in Table 2.1.

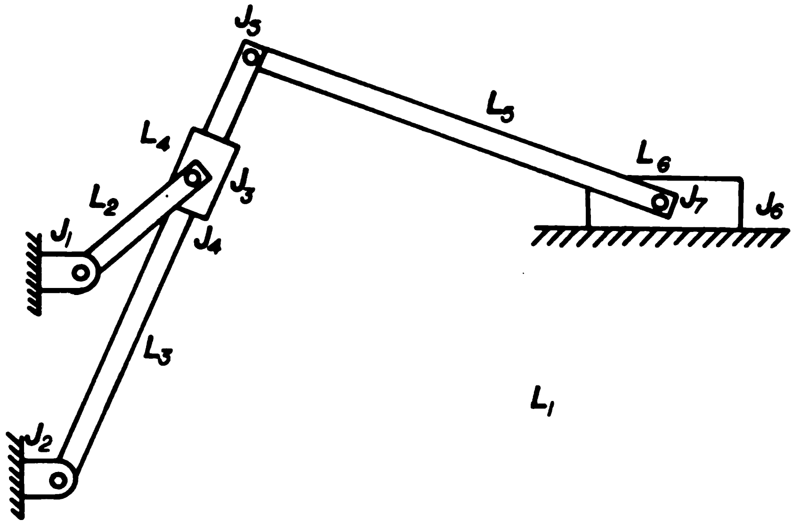


Figure 2.1 Skeleton Drawing of the Six Bar Quick-return Mechanism

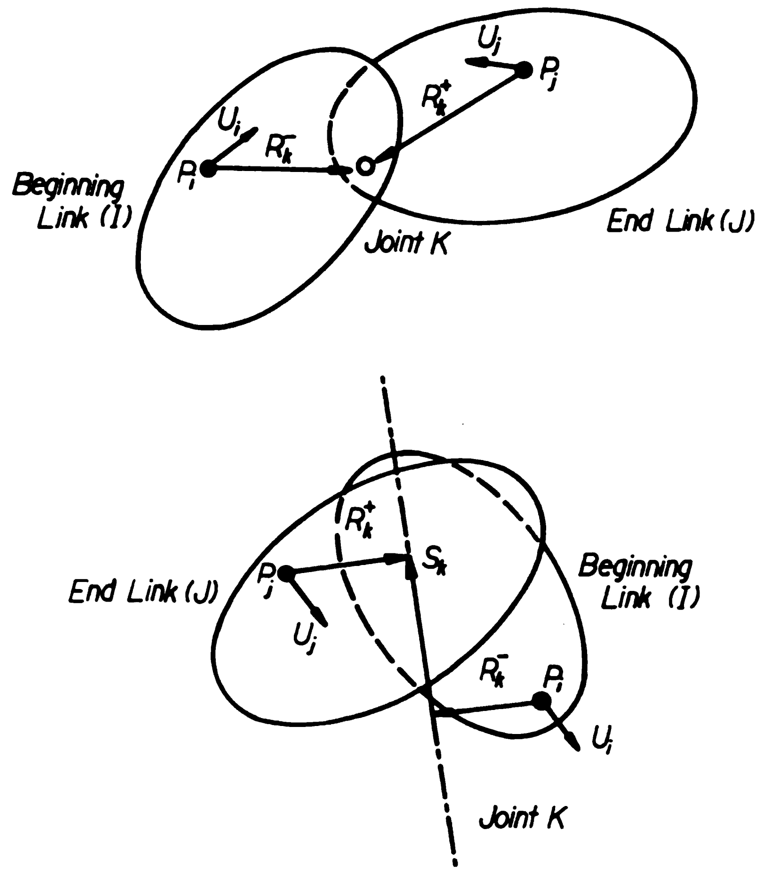


Figure 2.2 Mating Pair with Reference Point, Reference Unit Vector and R-vector

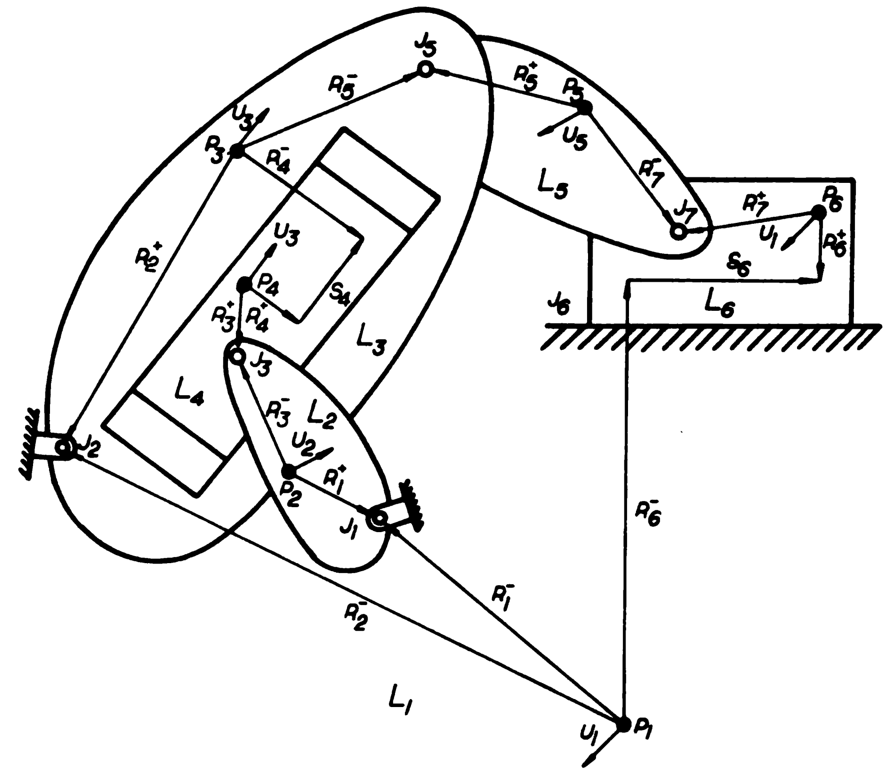


Figure 2.3 The Six Bar Quick-return Mechanism with R-vector

Table 2.1 Design Data for the Six Bar Quick-return Mechanism

Joint Number	r^-	α^-	r^+	α^+
1	r_1^-	α_1^-	r_1^+	α_1^+
2	r_2^-	α_2^-	r_2^+	α_2^+
3	r_3^-	α_3^-	r_3^+	α_3^+
4	r_4^-	α_4^-	r_4^+	α_4^+
5	r_5^-	α_5^-	r_5^+	α_5^+
6	r_6^-	α_6^-	r_6^+	α_6^+
7	r_7^-	α_7^-	r_7^+	α_7^+

2.3 System Parameter Data

System parameters are those quantities which vary as the kinematic chain changes position. They are the angle of the reference unit vectors with respect to ground and the length of the slip vectors.

The system parameter data are represented by a one-dimensional array. Table 2.2 shows the system parameter data for the six bar quick-return mechanism.

2.4 Indexing Data

Indexing Data consist of two one-dimensional arrays, the Beginning Indexing Array (BIA) and the End Indexing Array (EIA). The BIA and the EIA contain the locations of the angles of the reference unit vectors corresponding to the Beginning Links and End Links, respectively. Table 2.3 shows the indexing data for the six bar quick-return mechanism.

In the following sections, a procedure for generating these data is discussed.

Table 2.2 System Parameter Data for the Six Bar Quick-return Mechanism

Index	System Parameter
1	θ_1
2	θ_2
3	θ_3
4	s_4
5	θ_4
6	s_6

Table 2.3 Indexing Data for the Six Bar Quick-return Mechanism

Joint Number	BIA	EIA
1	1	2
2	1	3
3	2	3
4	-3	-3
5	3	5
6	-1	-1
7	1	5

CHAPTER III

HARDWARE

Evans and Sutherland PS 300 system is used in this project because of its graphic capabilities[22]. It consists of a graphical terminal, a Data Tablet, and a Control Dials Unit, see Figure 3.1. The host computer is PRIME 750. The graphical portion of the program is handled by PS 300 local function actions and non-graphical portion of the program is carried on the PRIME 750. All of the hardware used in this project is available in the Case Center, Engineering Building, Michigan State University.

Data Tablet and Control Dials Unit are used as interactive devices. The Data Tablet includes a pad and a stylus. By moving the stylus on the pad or pressing the stylus down on the pad to activate the tipswitch, a digitized representation of the stylus location on the pad can be sent to PS 300 system. The location information is used to perform the functions of menu selection, pointing, and picking.

Control Dials Unit is used to send numeric values to PS 300

Figure 3.1 Hardware Configuration

system as degrees of rotation and distances of translation. By rotating Control Dials, a predefined object on the screen can be rotated and be translated accordingly.

CHAPTER IV

SOFTWARE

4.1 Basic Considerations

The programs developed here intend to create a truely user-friendly environment for computer-aided-design of mechanisms. The procedures of creating mechanisms are carefully designed so that they resemble the assemblage of the actual mechanism. Any planar mechanism with lower pairs joint, pin joint and sliding joint, with any degrees of freedom and any number of links, joints, and loops can be constructed. Afterwards, the user can play with this mechanism on the terminal screen just like playing a real mechanism prototype.

The menu-driven and computer-initiated features make the designing of mechanisms easy and simple even for those who do not know mnemonics and codes for computer. Menu and instructions are provided at every step, so that the user interacts with system with ease. The instructions contain the information of the current status and the information of the actions should be taken by the user.

In order to achieve more efficient man-computer communication, the amount of information typed from the Keyboard is minimized. Most procedures are performed through Stylus and Control Dials Unit to enable the user to focus on the screen. Only digital inputs are typed from the Keyboard.

Menus are placed at the lower right corner of the screen for easy touch of the Stylus(Figure 4.1). The instructions are also shown at the lower right corner above the menu. If menu is not used to select the next step, the instructions will be placed in the menu section in order to draw user's attention. The mechanism must not be defined within the menu section. Because it will cause ambiguous picking result. Thus, the system is designed not to accept any digitized data from the menu section except for menu selection.

4.2 Program Structure

The program structure is based on the tree structure, Figure 4.2. The driver program can invoke two other programs: the preprocessor and the postprocessor. The preprocessor has two modes of operation, the create and edit modes. In the create mode a new mechanism can be defined. In the edit mode an existing mechanism can be modified by adding new elements, removing elements from it, or changing the connections of the elements. The preprocessor keeps a record of the actions taken in the create

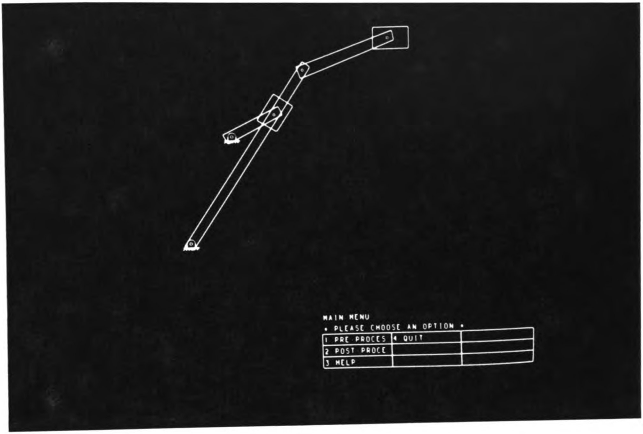


Figure 4.1 A Menu Shown on the Terminal Screen

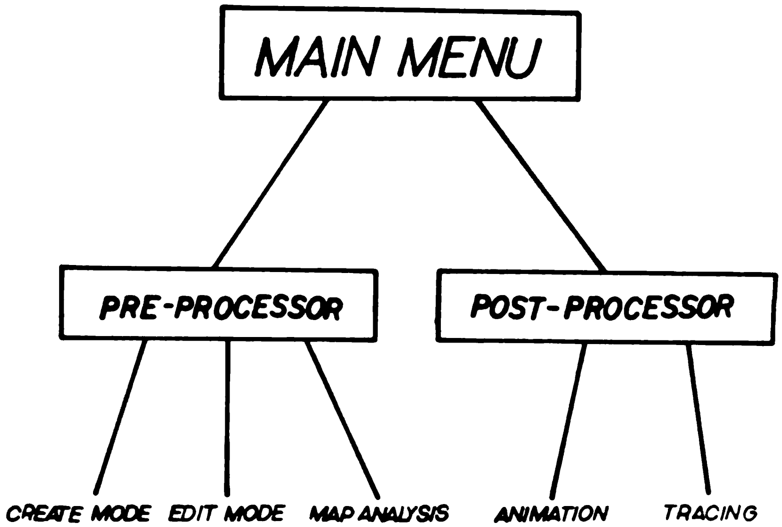


Figure 4.2 Flow Chart

mode and edit mode and generates an input file for MAP[1,2](an automated procedure for analysis of mechanisms). MAP analyzes the mechanism and generates an input file for the postprocessor.

The postprocessor uses the output from MAP to animate the motion of the mechanism. It also draws the trace of any point on any link specified by the user.

4.3 Preprocessor Command Descriptions

Table 4.1 is a list of available commands in the preprocessor. First four commands in the listing are used in the create mode and the next three commands are used in the edit mode. The ninth command initiates the process of generating the input data for MAP. The following are the descriptions of each command in the create mode and edit mode.

4.3.1 Create Mode

The basic components of mechanisms, links, joints, and forcing agents, are created individually in this mode. The useful commands are:

1. CREATE LNK (create link)
2. TRANS LNK (translate link)
3. CREATE JNT (create joint)
4. CREATE FA (create forcing agent).

Table 4.1 A List of Commands in the Preprocessor

1. CREATE LNK (create links)
2. TRANS LNK (translate links)
3. CREATE JNT (create joints)
4. CREATE FA (create forcing agents)
5. DELETE LNK (delete links)
6. DELETE JNT (delete joints)
7. DELETE FA (delete forcing agents)
8. EXIT
9. ANALYSIS (analysis by MAP)

The above sequence is recommended to create a mechanism.

In the CREATE LNK command, links can be drawn in any shapes the boundaries of which are line segments. This is done by implementing the rubber band technique(Figure 4.3). The link can be relocated to any place, so user can concentrate on drawing the shape of the link while creating it. Control Dials Unit is used for translating the links. The LED displays with the message ROTATE, X-DIR, and Y-DIR come on the Control Dials Unit to indicate whitch dials should be operated for the rotation and translation of the selected links.

To create a joint three steps are taken. The first step is to specify the joint type. A menu is provided for joint type selection. The second step is the positioning of the joints. The positioning of a joint here is meant to specify the location of the pin joint and the line of sliding for the slider joint. The third step is to specify the links which are connected by this joint.

To create a forcing agent, first, the user should choose the type of the forcing agent using the menu. The information for the complete description of a forcing agent such as the force-displacement or force-velocity relations of the forcing agent and the locations of the terminal points of the forcing agents should be provided.

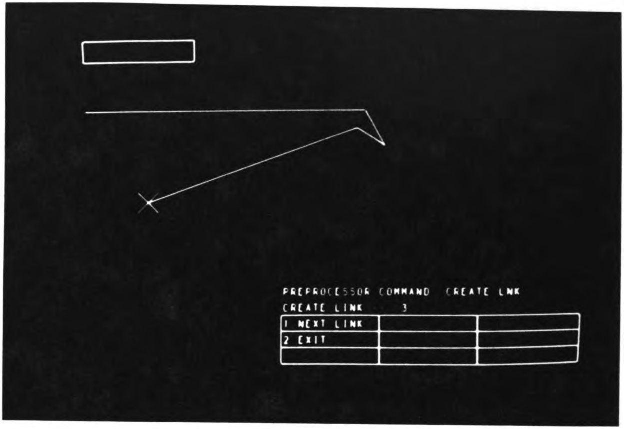


Figure 4.3 The Use of Rubber Band Technique to Draw a Link

4.3.2 Edit Mode

The commands which could be used to modify mechanisms are:

5. DELETE LNK(delete links)
6. DELETE JNT(delete joints)
7. DELETE FA (delete forcing agents).

To delete elements such as links, joints, and forcing agents, the user is asked to pick an element first. Then this element will be deleted from the screen.

The delete and create commands can be combined to edit a mechanism. For example, in order to change the shape of a link, one should delete that link first and create the link with the desired shape.

4.4 Generation of the Data for Mechanisms

Generation of the data of a mechanism as described in Chapter II, is the prime objective of the preprocessor. A group of information is collected in the process of create a mechanism, and the other is calculated by the program. The data given during the create phase are the shape and position of a link in the create link command, and the type, location, Beginning Link, and End Link of a joint in the create joint command. For simplicity, the reference point on each link is placed at the center of mass of each link. The reference unit vectors are set parallel to the X-axis.

As stated before, the graphical portion is handled by PS 300 system, so the shape of link is stored in PS 300 local memory. Only the coordinates of center of mass of each link are calculated by the program as the reference point. If a link is translated to another place by the TRANS LNK(translate link) command, only the new coordinates of center of mass are needed to describe this new situation.

Then, the information described above is enough to calculate Connectivity Data, Design Data, System Parameter Data, and Indexing Data of the mechanism. The Beginning Branch Vector and End Branch Vector of Connectivity Data is directly given by the user during the third step of creating joint. Design Data can be calculated from the joint position to the center of mass of the Beginning Link and End Link of each joint.

To set up the System Parameter Data, the first step is to assign a reference unit vector to every link. If a joint is a pin joint then two different reference unit vectors are assigned to the Beginning Link and End Link, respectively. But only one reference unit vector is assigned to both Beginning Link and End Link of a sliding joint. Because the reference unit vectors on the Beginning Link and End Link of a slider joint have the same direction. An Index number is assigned to each newly introduced reference unit vector, if this Index number is not a sliding joint number. If the Index number is a sliding joint number, the System Parameter Data is the length of the slip vector. Otherwise, the System Parameter Data are the angle between the reference unit vectors and the X-axis.

To define the Indexing Data, the entries of BIA and EIA are the reference unit vector number of the Beginning Links and the End Links.

After the data generation is completed, MAP is used to analyze the mechanism. MAP generates a file named DPS for animation of the mechanism and drawing the paths. File DPS contains the position of the center of mass and the rotation angle of each link at every time steps.

4.5 Postprocessor

There are two modes in postprocessor: ANIMATION and TRACING. They are used in seeing the motion of whole mechanism and the tracing of the specific point which are very useful in designing a mechanism.

In the ANIMATION mode, the user is able to visualize the motion of the mechanism. Animation provides a visual check for the interferences between the links and housing or for the poor transmission angles. The set of commands that is used for control the apparent motion of the mechanism are:

1. STOP
2. START
3. STEP
4. SPEED UP
5. SLOW DOWN
6. REVERSE
7. INITIAL P.(initial position)
8. EXIT.

If the motion were stopped by STOP command, it could be restarted by START command or be incremented one step at a time by STEP command.

In the TRACING mode, upon specifying a point on any link, the system draws the path of that point. This is a useful tool for searching the path of desired shape which frequently addressed as a synthesis problem. The commands in the TRACING mode are:

1. NEW LINK

2. REM CURVES (remove all coupler curves)

3. DISP CURVE (display all coupler curves)

4. EXIT.

The NEW LINK command allows user to choose points on different links. Different symbols are used to represent the paths of points on the different links(Figure 4.4). REM CURVES command can remove all the paths from screen and DISP CURVE command can let all paths appear again.

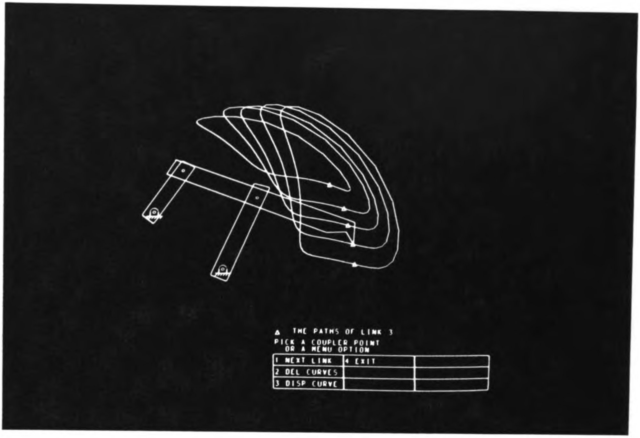


Figure 4.4 Coupler Curves

CHAPTER V

CONCLUSIONS

A procedure for creation and animation of planar mechanisms has been developed. It involves generating the data needed for analyzing mechanisms. These data are generated by using a computer graphic terminal and interactive input devices such as Stylus. The softwares which were developed included a preprocessor and a postprocessor. The preprocessor has the editing capability. This makes modifications of mechanisms become easier. The postprocessor enables the user to display the information relevant to the design of mechanisms conveniently.

This work could be expanded in two ways. One is extend the preprocessor and postprocessor to handle the dynamic and internal force part of MAP(the analysis program). The other is combining an automatic synthesis program and the preprocessor to enhance the synthesis capability.

Although the forcing agents can be defined using the preprocessor, but they are not used in kinematic analysis of the mechanism. They affect the dynamic and internal force analysis of the mechanism. Through the trial and error approach, the result of dynamic analysis can be used to reduce or redistribute the reaction forces and moments by adding counterweights to links or by changing the characteristics of forcing agents.

This package can be incorporated in an automatic mechanism synthesis program, in order to achieve easy interaction with computer. The user can specify an initial design of a mechanism using this package. Then an objective function is formed automatically as the measure of the difference between the desired motion specified by the user and the motion generated by the initial design. Having formed the objective function, an optimization technique can be used to conduct a systematic search for the optimum design. As a result, the motion of the optimized mechanism can be visualized and checked using this package.

APPENDIX A

PMAP USER'S MANUAL

A-1 INTRODUCTION

PMAP is an interactive computer program for kinematic analysis of any planar mechanisms. The program includes a preprocessor and a postprocessor. The preprocessor allows the user to draw planar mechanisms on an Evans and Sutherland PS-300 terminal using Data Tablet and Control Dials Unit. Then, the animation of the mechanism and the paths of any points can be shown on the terminal screen.

The basic components of a mechanism used in PMAP are link, joint, and forcing agent as summarized in Table A.1. The links can be created individually and connected by joints. So, the construction of a mechanism is similar to the procedure of assembling the actual mechanism parts.

All the procedures are menu-driven and computer initiated. Therefore, no computer background is required to use PMAP.

Table A.1 Basic Components of Mechanisms Used in PMAP

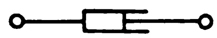
COMPONENT	SCHEMATIC DIAGRAM
LINK:	Arbitrary Shape
JOINT:	
Pin Joint	 or 
Sliding Joint	
FORCING AGENT:	
Spring	
Damper	

Figure A.1 shows all the menus available in PMAP. Main menu is the first menu displayed on the screen. The other menus are displayed according to the command being chosen. For example, if second command, POSTPROCES(sor), is chosen from main menu, then the main menu is replaced by the postprocessor menu in the menu section. The EXIT command, listed on almost every menu, is for 'go back' to the previous menu.

A-2 NORMAL PROCESS

Generally, the process starts from creating components of a mechanism by the first four commands in the preprocessor menu. They are:

1. CREATE LNK(create link)
2. TRANS LNK (translate link)
3. CREATE JNT(create joint)
4. CREATE FA (create forcing agent).

The above sequence is recommended to create a mechanism. After the mechanism construction, you can choose ANALYSIS command in the preprocessor menu to execute the analysis program. Then you can check the animation and coupler curves of the mechanism by the commands in postprocessor. If the results were not satisfactory, the program could go back to preprocessor menu in order to edit the mechanism. Figure A.2 shows the flowchart of normal

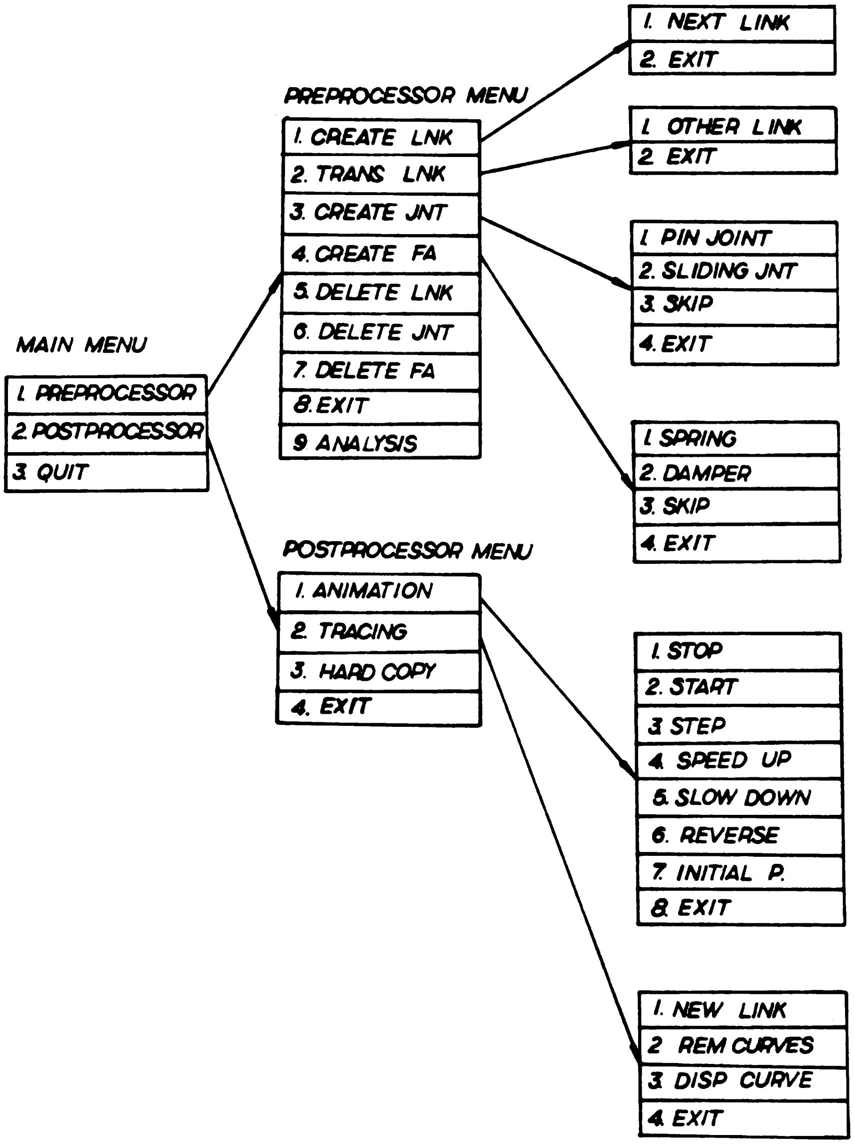


Figure A.1 Menus Available in PMAP

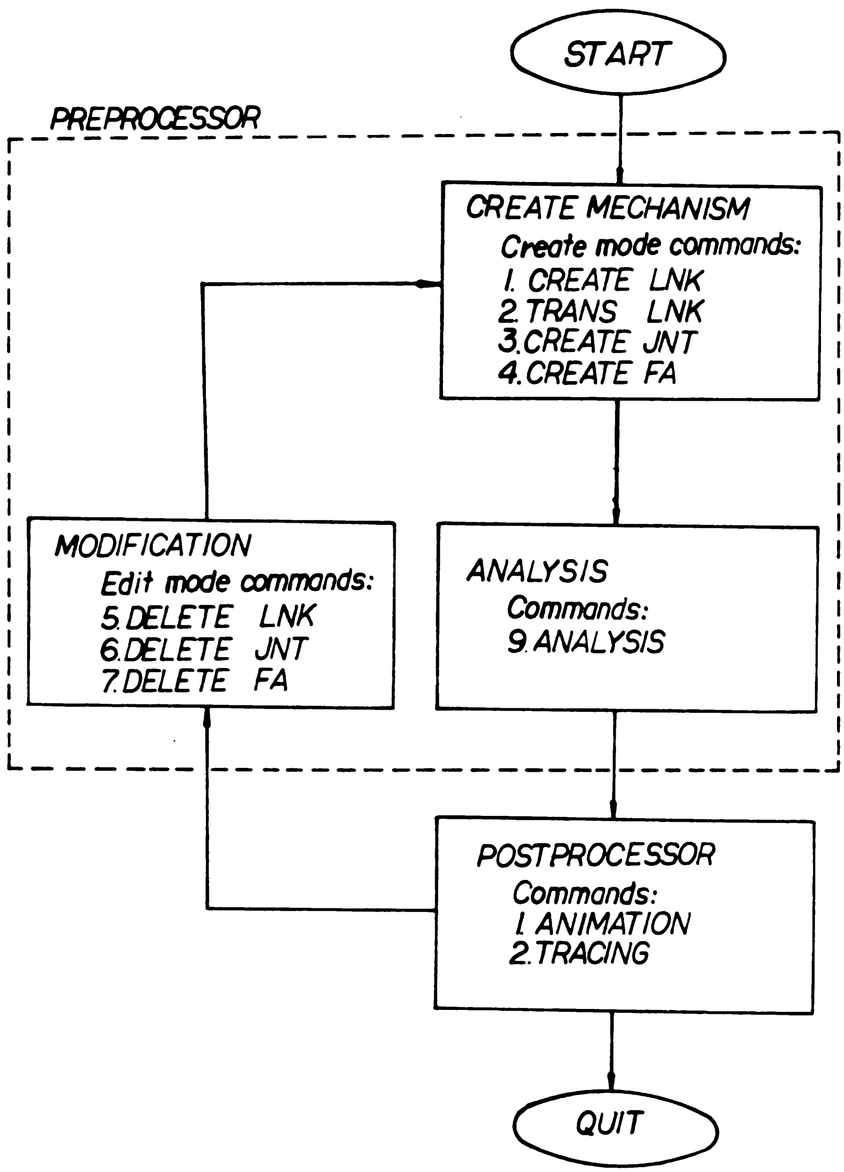


Figure A.2 Flow Chart of the Normal Procedures processing procedure.

A-3 DETAILED DESCRIPTIONS OF COMMANDS

Table A.2 is a list of commands available in PMAP. The following are detailed descriptions of commands in PMAP. They are grouped into preprocessor commands and postprocessor commands.

A-3.1 PREPROCESSOR COMMANDS

1. CREATE LNK (create link)

   Commands available in the menu now:

   1. NEXT LINK : create a new link
   2. EXIT : go back to preprocessor menu

You can use Stylus to draw links of arbitrary shapes by rubber band technique the boundaries of which are line segments. The current link number will be shown on the screen. If you are done with this link and want to create another link, choose NEXT LINK command. Then you can create a new link with the link number incremented by one. If EXIT command is chosen, the preprocessor menu will show up.

Table A.2 A List of Commands in PMAP

(i) Preprocessor commands

1.CREATE LNK : create links individually by Data Tablet

   1. NEXT LINK : create a new link

   2. EXIT : go back to preprocessor menu

2.TRANS LNK : move any link to any place by Control Dials Unit

   1. OTHER LINK: move another link

   2. EXIT : go back to preprocessor menu

3.CREATE JNT : create pin joint or sliding joint to connect links

   1. PIN JOINT : this joint is a pin joint

   2. SLIDIN JNT: this joint is a sliding joint

   3. SKIP : skip to the next joint

   4. EXIT : go back to preprocessor menu

4.CREATE FA : attach forcing agent to the mechanism

   1. SPRING : this forcing agent is a spring

   2. DAMPER : this forcing agent is a damper

   3. SKIP : skip to the next forcing agent

   4. EXIT : go back to preprocessor menu

5.DELETE LNK : delete links

6.DELETE JNT : delete joints

7.DELETE FA : delete forcing agents

8.EXIT : go back to main menu directly

9.ANALYSIS : perform analysis then go back to main menu

Table A.2 (cont'd)

(ii) Postprocessor commands

1. <u>ANIMATION</u> : animate the mechanism on the screen
   1. STOP :motion is stopped by this command
   2. START :motion is restarted by this command
   3. STEP :increment one step at a time
   4. SPEED UP :increase the speed
   5. SLOW DOWN :decrease the speed
   6. REVERSE :reverse the motion direction
   7. INITIAL P.:return to initial position
   8. EXIT : go back to postprocessor menu
2. <u>TRACING</u> :show the path of specific point
   1. NEW LINK : define the points on other link
   2. REM CURVES: delete all paths on the screen
   3. DISP CURVE: display paths which are deleted
   4. EXIT : go back to postprocessor menu
3. <u>HARD COPY</u> : get a hard copy from printer
4. <u>EXIT</u> : go back to main menu.

2. TRANS LNK (translate link)

Commands available in the menu now:

1. OTHER LINK: move another link
2. EXIT : go back to preprocessor menu

You can translate and rotate any link to any place by Control Dials Unit. First, you should response to the system by picking a link which you want to move using Stylus. Then the LED displays, X-DIR, Y-DIR, and ROTATE, show which dials should be operated. When you are done, you can move another link by choosing OTHER LINK command or you can go back to preprocessor menu by choosing EXIT command.

3.CREATE JNT (create joint)

Commands available in the menu now:

1. PIN JOINT : this joint is a pin joint
2. SLIDING JNT: this joint is a slider joint
3. SKIP : skip to the next joint
4. EXIT : go back to preprocessor menu

To create a joint, the following three steps should be taken. First, specify the joint type by selecting PIN JOINT or SLIDING JNT. Second, position the joint. If it is a pin joint, one needs to specify the coordinates of the pin joint by guiding the cursor to the desired position. If it is a sliding joint, one should specify two points to define the line of sliding. The third step is use Stylus to specify the two links which are connected by this joint. If the SKIP command is executed, then the next joint should be defined. If EXIT command executed, the control goes back to preprocessor.

4. CREATE FA (create forcing agent)

   Commands available in the menu now:

   1. SPRING : this forcing agent is a spring
   2. DAMPER : this forcing agent is a damper
   3. SKIP : skip to the next forcing agent
   4. EXIT : go back to preprocessor menu

To create a forcing agent the following three steps should be taken. First, specify the forcing agent type. This could be a spring or a damper. When you specify the type of the forcing agent at this step by SPRING or DAMPER, the first step is completed. If the SKIP command is chosen then the system is ready to accept the second forcing agent. If EXIT command is chosen the control goes to preprocessor. In the second step, one needs to provide the force-displacement relation of a spring or the force-velocity relation of a damper. The third step is to specify the location of the terminals of the forcing agent and the links to which the forcing agent is attached. The schematic diagram of the forcing agent is shown as it is defined.

5. DELETE LNK (delete link)

To delete a link, one should mark the cursor on the boundary of that link by Stylus. Then the link will disappear. Only one link can be deleted each time. After a link being deleted, one can use CREATE LNK command to create a link with different shape again. So, combining DELETE LNK and CREATE LNK commands is equivalent to editing the shape of a link.

6. DELETE JNT (delete joint)

A joint can be deleted through executing DELETE JNT command. If one wants to redefine this joint, CREATE JNT command should be used.

7. DELETE FA (delete forcing agent)

To remove a forcing agent, you can pick a forcing agent using Stylus. Then, that forcing agent is deleted. If one wants to edit a forcing agent, one should delete this forcing agent first. Then use CREATE FA command to redefine it again.

8. EXIT

go back to main menu directly.

9. ANALYSIS

If ANALYSIS command were chosen, the system will request the idenfication of input links. This is done by moving the cursor to the edge of the input link by Stylus and push it down. At this point the mechanism created in preprocessor is completed. It can be analyzed through executing the ANALYSIS command. After analysis is completed, execute the postprocessor.

A-3.2 POSTPROCESSOR COMMANDS

1. ANIMATION

Commands available in the menu are:

1. STOP :motion is stopped by this command
2. START :motion is restarted by this command
3. STEP :increment one step at a time
4. SPEED UP :increase the speed
5. SLOW DOWN :decrease the speed
6. REVERSE :reverse the motion direction
7. INITIAL P. :return to initial position
8. EXIT :go back to postprocessor menu

Upon executing ANIMATION command, the motion of the mechanism is visualized. The apparent motion of the mehanism is controlled by the set of commands shown above. If the motion is stopped by the STOP command, it can be restarted by the START command or incremented one step at a time by the STEP command. SPEED UP and SLOW DOWN commands can accelerate or decelerate the motion of the mechanism.

2. TRACING

Commands available in the menu are:

1. NEW LINK : define the points on other link
2. REM CURVES: delete all paths on the screen
3. DISP CURVE: display paths which are deleted
4. EXIT : go back to postprocessor menu

The TRACING command draws the path of any specified point. After your response to the system to locate the point of interest and the link on which this point belongs, the system draws the path of this point. More than one point can be chosen and the system draws their paths. If the path of a point on another link is desired, one can execute NEW LINK command. If you want to erase the paths then execute the REM CURVES(remove curves) command. The DISP CURVE(display curves) command puts the paths back on the screen.

3. HARD COPY

If you want a hard copy of the mechanism and the paths from printer, you may choose this command.

4. EXIT

go back to main menu.

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