



The eleventh in a series of tutorials for the beginner to intermediate machine language programmer

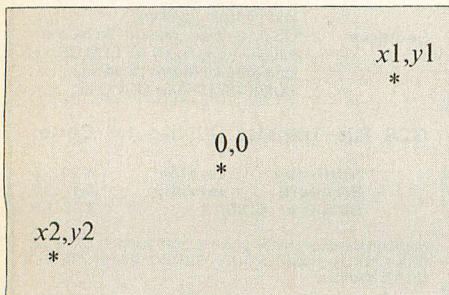
Machine Language Made BASIC

Part XI: 3-D Without Glasses

By William P. Nee

In last month's article about 2-D rotation, everything was plotted symmetrically and we didn't have to pay any attention to location. Now we will be discussing 3-D, and it becomes more important to visualize where we are actually plotting our points.

Think of the center of the screen as 0,0,0 — that is, zero x, zero y, and zero z. Numbers or bits to the right of the center are +x and those to the left of the center are -x. Numbers or bits above the center are +y and below the center are -y. Numbers or bits between you and the screen are -z, and behind the screen are +z. The z numbers or bits, of course, are not really there, but they must be taken into consideration when rotating points. We still only PSET the x and y coordinates.



| | | |
|------------------------|------------------------|------------------------|
| ROTATE AROUND X AXIS | ROTATE AROUND Y AXIS | ROTATE AROUND Z |
| Y1 = Y * COS - Z * SIN | Z1 = Z * COS - X * SIN | X1 = X * COS - Y * SIN |
| Z1 = Y * SIN + Z * COS | X1 = Z * SIN + X * COS | Y1 = X * SIN + Y * COS |
| X1 = X | Y1 = Y | Z1 = Z |

Figure 1

Listing 1: ROTATE3D

```

4F00          00100          ORG          $4F00
4F00 108E 5200  00110  START  LDY          #$5200
4F04 10BF 5080  00120          STY          COORD  START OF COORDINATES
4F08 F6 5085   00130          LDB          NUMBER  HOW MANY DOTS TO SET
4F0B F7 5082   00140          STB          COUNT
4F0E C6 32     00150  RNDX   LDB          #50
4F10 BD BC7C   00160          JSR          $BC7C  REGISTER B TO FPI
4F13 BD BF1F   00170          JSR          $BF1F  RND(50)
4F16 BD B3ED   00180          JSR          $B3ED  PUT IT BACK IN REGISTER B
4F19 1E 89     00190          EXG          A,B  MAKE IT A 2-BYTE NUMBER
4F1B ED A4     00200          STD          ,Y   +X
4F1D ED 26     00210          STD          6,Y  +X
4F1F ED 2C     00220          STD          12,Y +X
4F21 ED A8 12  00230          STD          18,Y +X
4F24 40        00240          NEGA
4F25 ED A8 18  00250          STD          24,Y  -X
4F28 ED A8 1E  00260          STD          30,Y  -X
4F2B ED A8 24  00270          STD          36,Y  -X
4F2E ED A8 2A  00280          STD          42,Y  -X
4F31 C6 32     00290  RNDY   LDB          #50
4F33 BD BC7C   00300          JSR          $BC7C  REGISTER B TO FPI
4F36 BD BF1F   00310          JSR          $BF1F  RND(50)
4F39 BD B3ED   00320          JSR          $B3ED  PUT IT BACK IN REGISTER B
4F3C 1E 89     00330          EXG          A,B  MAKE IT A 2-BYTE NUMBER
4F3E ED 22     00340          STD          2,Y   +Y
4F40 ED 28     00350          STD          8,Y   +Y
4F42 ED A8 1A  00360          STD          26,Y  +Y
4F45 ED A8 20  00370          STD          32,Y  +Y
4F48 40        00380          NEGA
4F49 ED 2E     00390          STD          14,Y  -Y
4F4B ED A8 14  00400          STD          20,Y  -Y
4F4E ED A8 26  00410          STD          38,Y  -Y
4F51 ED A8 2C  00420          STD          44,Y  -Y
4F54 C6 32     00430  RNDZ   LDB          #50
4F56 BD BC7C   00440          JSR          $BC7C  REGISTER B TO FPI
4F59 BD BF1F   00450          JSR          $BF1F  RND(50)
4F5C BD B3ED   00460          JSR          $B3ED  PUT IT BACK IN REGISTER B
4F5F 1E 89     00470          EXG          A,B  MAKE IT A 2-BYTE NUMBER
4F61 ED 24     00480          STD          4,Y   +Z
4F63 ED A8 10  00490          STD          16,Y  +Z
    
```

Bill Nee bucked the "snowbird" trend by retiring to Wisconsin from a banking career in Florida. He spends the long, cold winters writing programs for his CoCo.

| | | | | |
|-----------------|-------|------|----------|------------------------------|
| 4F66 ED A8 1C | 00500 | STD | 28,Y | +Z |
| 4F69 ED A8 28 | 00510 | STD | 40,Y | +Z |
| 4F6C 40 | 00520 | NEGA | | |
| 4F6D ED 2A | 00530 | STD | 10,Y | -Z |
| 4F6F ED A8 16 | 00540 | STD | 22,Y | -Z |
| 4F72 ED A8 22 | 00550 | STD | 34,Y | -Z |
| 4F75 ED A8 2E | 00560 | STD | 46,Y | -Z |
| 4F78 31 A8 30 | 00570 | LEAY | 48,Y | NEXT COORDINATE LOCATION |
| 4F7B 7A 5082 | 00580 | DEC | COUNT | FINISHED ALL THE DOTS YET? |
| 4F7E 26 8E | 00590 | BNE | RNDX | |
| 4F80 C6 05 | 00600 | LDB | #5 | |
| 4F82 BD 9653 | 00610 | JSR | \$9653 | |
| 4F85 BD 9542 | 00620 | JSR | \$9542 | PCLS |
| 4F88 8D 1F | 00630 | BSR | PICK | WHICH AXIS TO ROTATE AROUND? |
| 4F8A 8D 48 | 00640 | BSR | LOOP5 | COMPUTE AND SET POINTS |
| 4F8C C6 01 | 00650 | LDB | #1 | GRAPHICS SCREEN |
| 4F8E BD 95AA | 00660 | JSR | \$95AA | |
| 4F91 C6 01 | 00670 | LDB | #1 | |
| 4F93 BD 9653 | 00680 | JSR | \$9653 | |
| 4F96 BD 9542 | 00690 | JSR | \$9542 | PCLS |
| 4F99 8D 0E | 00700 | BSR | PICK | WHICH AXIS TO ROTATE AROUND? |
| 4F9B 8D 37 | 00710 | BSR | LOOP5 | COMPUTE AND SET POINTS |
| 4F9D C6 01 | 00720 | LDB | #1 | GRAPHICS SCREEN |
| 4F9F BD 95AA | 00730 | JSR | \$95AA | |
| 4FA2 AD 9F A000 | 00740 | JSR | [\$A000] | ANY INPUT? |
| 4FA6 27 D8 | 00750 | BEQ | PAGE5 | IF NOT, BACK TO PAGE5 |
| 4FA8 39 | 00760 | RTS | | END OF THE PROGRAM |
| 4FA9 C6 03 | 00770 | LDB | #3 | THERE ARE 3 AXIS |
| 4FAB BD BC7C | 00780 | JSR | \$BC7C | REGISTER B TO FP1 |
| 4FAE BD BF1F | 00790 | JSR | \$BF1F | RND(3) |
| 4FB1 BD B3ED | 00800 | JSR | \$B3ED | PUT IT BACK IN REGISTER B |
| 4FB4 C1 01 | 00810 | CMPB | #1 | IS IT X ROTATION |
| 4FB6 26 08 | 00820 | BNE | YROTAT | BRANCH IF NOT |
| 4FB8 8E 5202 | 00830 | LDX | #\$5202 | FIRST Y COORDINATE |
| 4FBB 108E 5204 | 00840 | LDY | #\$5204 | FIRST Z COORDINATE |
| 4FBF 39 | 00850 | RTS | | |
| 4FC0 C1 02 | 00860 | CMPB | #2 | IS IT Y ROTATION |
| 4FC2 26 08 | 00870 | BNE | ZROTAT | BRANCH IF NOT |
| 4FC4 8E 5204 | 00880 | LDX | #\$5204 | FIRST Z COORDINATE |
| 4FC7 108E 5200 | 00890 | LDY | #\$5200 | FIRST X COORDINATE |

Since the Color Computer numbers from the top of the screen down, we change the y direction a little. Look at the following diagram:

If you want to set a point (x1,y1) at coordinates (+12,+16), what is the actual screen location? Since the x1 location is to the right of the center, it's location is 128+x1; since the y1 location is above the center, it's location is 96-y1. The screen location is then 140,80. If x2 is -20 and y2 is -30, its screen location is 128+(-20),96-(-30), or 108,126. It is the x,y (and z) coordinates that are stored and rotated, not the screen locations.

In last month's article we actually revolved points around the z axis although we just called it rotating. Now we need a formula to rotate around the x axis, a horizontal line through the center of the screen, and the y axis, a vertical line through the center of the screen. As before, x, y and z are the old locations and x1, y1 and z1 are the new rotated locations. (See Figure 1.)

Since we are using the same angle of rotation in all three cases (see last month's article), all three formulas are the same — just the x, y and z are



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different. Again, it is only the x and y screen locations that are actually PSET.

The machine-language program picks a set of 25 random coordinates between 1 and 50 for x , y and z . Since the pattern is symmetrical, there are actually eight coordinate points computed and rotated:

x, y, z $x, -y,$ $-x, y, z$ $-x, -y, z$
 $x, y, -z$ $x, -y, -z$ $-x, y, -z$ $-x, -y, -z$

“After picking an axis of rotation, the program computes the other two coordinate’s rotated position, but the axis coordinate remains unchanged.”

Our coordinate table, which is two bytes for each x , y , and z coordinate, starts at \$5200. The first x coordinate is stored in locations \$5200 +0, +6, +12 and +18; the negative x coordinate is stored at \$5200 +24, +30, +36 and +42. The first y coordinate is stored at \$5200 +2, +8, +26 and +32; the negative y coordinate is stored at \$5200 +14, +20, +38 and +44. The first z coordinate is stored at \$5200 +4, +16, +28 and +40; the negative z coordinate is stored at \$5200 +10, +22, +34 and +46.

So starting at \$5200 we have: + x , 0, + y , 0, + z , 0, + x , 0, + y , 0, - z , 0, + x , 0, - y , 0, + z , 0, + x , 0, - y , 0, - z , 0, - x , 0, + y , 0, + z , 0, -, 0, + y , 0, - z , 0, - x , 0, - y , 0, + z , 0, - x , 0, - y , 0, - z , 0. The coordinate table is then increased by 48 to get the start of the next group at \$5230. The amount in NUMBER (FCB 25) is the number of initial sets of coordinates, and eight times this number is stored and plotted. You can make the amount higher or lower as you want.

Since we run the program from BASIC, we do not need to set the PMODE or color. After setting Page 5, the computer randomly selects the axis of rotation. Remember that \$5200 is the location of the first x coordinate, \$5202

| | | | | | |
|-----------|------|-------|--------|------|---------------------------------|
| 4FCB 39 | | 00900 | RTS | | |
| 4FCC 8E | 5200 | 00910 | ZROTAT | LDX | #5200 FIRST X LOCATION |
| 4FCF 108E | 5202 | 00920 | | LDY | #5202 FIRST Y LOCATION |
| 4FD3 39 | | 00930 | RTS | | |
| 4FD4 CE | 7000 | 00940 | LOOP5 | LDU | #7000 LOCATION OF "SCRATCH PAD" |
| 4FD7 F6 | 5085 | 00950 | | LDB | NUMBER |
| 4FDA 86 | 08 | 00960 | | LDA | #8 SET 8 POINTS PER COORDINATE |
| 4FDC 3D | | 00970 | | MUL | |
| 4FDD FD | 5083 | 00980 | LOOP3 | STD | COUNT1 |
| 4FE0 EC | 84 | 00990 | | LDD | ,X |
| 4FE2 ED | C4 | 01000 | | STD | ,U |
| 4FE4 ED | 44 | 01010 | | STD | 4,U |
| 4FE6 47 | | 01020 | | ASRA | |
| 4FE7 56 | | 01030 | | RORB | |
| 4FE8 47 | | 01040 | | ASRA | |
| 4FE9 56 | | 01050 | | RORB | |
| 4FEA 47 | | 01060 | | ASRA | |
| 4FEB 56 | | 01070 | | RORB | |
| 4FEC 47 | | 01080 | | ASRA | |
| 4FED 56 | | 01090 | | RORB | |
| 4FEE 47 | | 01100 | | ASRA | |
| 4FEF 56 | | 01110 | | RORB | |
| 4FF0 47 | | 01120 | | ASRA | |
| 4FF1 56 | | 01130 | | RORB | |
| 4FF2 47 | | 01140 | | ASRA | |
| 4FF3 56 | | 01150 | | RORB | |
| 4FF4 ED | 42 | 01160 | | STD | 2,U |
| 4FF6 EC | C4 | 01170 | | LDD | ,U |
| 4FF8 A3 | 42 | 01180 | | SUBD | 2,U |
| 4FFA ED | C4 | 01190 | | STD | ,U |
| 4FFC EC | A4 | 01200 | | LDD | ,Y |
| 4FFE 47 | | 01210 | | ASRA | |
| 4FFF 56 | | 01220 | | RORB | |
| 5000 47 | | 01230 | | ASRA | |
| 5001 56 | | 01240 | | RORB | |
| 5002 47 | | 01250 | | ASRA | |
| 5003 56 | | 01260 | | RORB | |
| 5004 ED | 42 | 01270 | | STD | 2,U |
| 5006 EC | C4 | 01280 | | LDD | ,U |
| 5008 A3 | 42 | 01290 | | SUBD | 2,U |
| 500A ED | 84 | 01300 | | STD | ,X |
| 500C EC | A4 | 01310 | NEWY | LDD | ,Y |
| 500E ED | 46 | 01320 | | STD | 6,U |
| 5010 ED | 48 | 01330 | | STD | 8,U |
| 5012 EC | 44 | 01340 | | LDD | 4,U |
| 5014 47 | | 01350 | | ASRA | |
| 5015 56 | | 01360 | | RORB | |
| 5016 47 | | 01370 | | ASRA | |
| 5017 56 | | 01380 | | RORB | |
| 5018 47 | | 01390 | | ASRA | |
| 5019 56 | | 01400 | | RORB | |
| 501A ED | 44 | 01410 | | STD | 4,U |
| 501C EC | 48 | 01420 | | LDD | 8,U |
| 501E 47 | | 01430 | | ASRA | |
| 501F 56 | | 01440 | | RORB | |
| 5020 47 | | 01450 | | ASRA | |
| 5021 56 | | 01460 | | RORB | |
| 5022 47 | | 01470 | | ASRA | |
| 5023 56 | | 01480 | | RORB | |
| 5024 47 | | 01490 | | ASRA | |
| 5025 56 | | 01500 | | RORB | |
| 5026 47 | | 01510 | | ASRA | |
| 5027 56 | | 01520 | | RORB | |
| 5028 47 | | 01530 | | ASRA | |
| 5029 56 | | 01540 | | RORB | |
| 502A 47 | | 01550 | | ASRA | |
| 502B 56 | | 01560 | | RORB | |
| 502C ED | 48 | 01570 | | STD | 8,U |
| 502E EC | 46 | 01580 | | LDD | 6,U |
| 5030 A3 | 48 | 01590 | | SUBD | 8,U |
| 5032 E3 | 44 | 01600 | | ADDD | 4,U |
| 5034 ED | A4 | 01610 | | STD | ,Y |
| 5036 30 | 06 | 01620 | | LEAX | 6,X |
| 5038 31 | 26 | 01630 | | LEAY | 6,Y |
| 503A FC | 5083 | 01640 | | LDD | COUNT1 |
| 503D 83 | 0001 | 01650 | | SUBD | #1 |
| 5040 1026 | FF99 | 01660 | | LBNE | LOOP3 |
| 5044 CE | 5200 | 01670 | GET | LDU | #5200 |
| 5047 F6 | 5085 | 01680 | | LDB | NUMBER |
| 504A 86 | 08 | 01690 | | LDA | #8 SET 8 POINTS PER COORDINATE |
| 504C 3D | | 01700 | | MUL | |
| 504D FD | 5083 | 01710 | LOOP6 | STD | COUNT1 |
| 5050 86 | 60 | 01720 | | LDA | #96 |
| 5052 A0 | 42 | 01730 | | SUBA | 2,U GET ACTUAL Y COORDINATE |
| 5054 C6 | 20 | 01740 | | LDB | #32 BYTES PER LINE |

```

5056 3D          01750      MUL
5057 9B  BA      01760      ADDA  $BA  GRAPHICS START
5059 1F  01      01770      TFR   D,X  REGISTER D TO REGISTER X
505B E6  C4      01780      LDB   ,U  ROTATED X COORDINATE
505D CB  80      01790      ADDB  #128 ACTUAL X COORDINATE ON SCREEN
505F 54          01800      LSRB  8 BITS PER BYTE
5060 54          01810      LSRB
5061 54          01820      LSRB
5062 3A          01830      ABX           ADD TO REGISTER X; = BYTE
5063 86  80      01840      LDA   #128
5065 AB  C4      01850      ADDA  ,U  GET ACTUAL X COORDINATE
5067 84  07      01860      ANDA  #7   CONVERT TO A NUMBER 0 - 7
5069 108E 92DD  01870      LDY   #92DD OR TABLE LOCATION IN ROM
506D E6  84      01880      LDB   ,X  GET CURRENT BYTE CONTENTS
506F EA  A6      01890      ORB   A,Y OR IT WITH OR TABLE
5071 E7  84      01900      STB   ,X  PSET NEW BYTE CONTENTS
5073 33  46      01910      LEAU  6,U NEXT COORDINATE LOCATION
5075 FC  5083    01920      LDD   COUNT1
5078 83  0001    01930      SUBD  #1
507B 1026 FFCE  01940      LBNE  LOOP6 ALL DONE YET?
507F 39          01950      RTS
5080          01960      COORD RMB  2
5082          01970      COUNT RMB  1
5083          01980      COUNT1 RMB  2
5085          19      01990      NUMBER FCB  25
                    4F00    02000      END    START

```

00000 TOTAL ERRORS

is the location of the first y coordinate, and \$5204 is the location of the first z coordinate.

After picking an axis of rotation, the program computes the other two coordinate's rotated position, but the axis coordinate remains unchanged. The end of the program PSETS the x and y screen locations. Pressing any key stops the program and returns to BASIC.

Instead of using the machine language program to pick the x, y and z coordinates, you can use your own program. The BASIC *Alternate 3-D* program is an example of this. Just remember to poke the following locations with:

&H5085 - NUMBER OF DOTS (ND)
 &H5200 - START OF COORDINATES
 &H4F80 - NEW EXECUTION ADDRESS

Listing 2: DRIVER

```

0 ' COPYRIGHT 1989  FALSOFT, INC
5 REM DRIVER PROGRAM
10 PCLEAR8: CLEAR200, &H4F00-1

```

```

20 X=RND(-TIMER)
30 PMODE 4,1:PCLS:SCREEN 1,1
40 EXEC &H4F00
50 GOTO 50

```

Listing 3: ALTROTAT

```

0 ' COPYRIGHT 1989  FALSOFT, INC
5 REM ALTERNATE 3D PROGRAM
10 PCLEAR8: CLEAR200, &H4F80-1
20 X=RND(-TIMER):ND=30:P=&H5200
30 CLS:POKE &H5085,ND:PRINT@200,
"CLEARING -"
40 FOR N=0 TO ND*8:POKE P+N,0:NE
XT:CLS
50 PRINT@200,"COUNTING DOWN -"
60 FOR T=1 TO ND:PRINT@216,ND-T+
1
70 X=60*COS(T):Y=60*SIN(T):Z=60*
TAN(T*ATN(1)/45)
80 X=ABS(X):Y=ABS(Y):Z=ABS(Z)
90 XX=256-X:YY=256-Y:ZZ=256-Z
100 POKE P,X:POKE P+6,X:POKE P+1
2,X:POKE P+18,X
110 POKE P+2,Y:POKE P+8,Y:POKE P
+26,Y:POKE P+32,Y
120 POKE P+4,Z:POKE P+16,Z:POKE
P+28,Z:POKE P+40,Z
130 POKE P+24,XX:POKE P+30,XX:PO
KE P+36,XX:POKE P+42,XX
140 POKE P+14,YY:POKE P+20,YY:PO
KE P+38,YY:POKE P+44,YY
150 POKE P+10,ZZ:POKE P+22,ZZ:PO
KE P+34,ZZ:POKE P+46,ZZ
160 P=P+48:NEXT
170 PMODE 4,1:PCLS:SCREEN 1,1
180 EXEC &H4F80
190 GOTO 190

```

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