Full Size Eight-sided Polygon, Attempt One

File: "FullSize8SidedPolygonAttemptOne.docx"

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Introduction

When young Tod Loofbourrow designed the somewhat famous MicroTron ("Mike" for short) robot, he did so based on the availability and design of the Herbach & Rademan TM20K370 motorized caster wheels. This was in the sumer of 1976 when Tod was but a wee lad of fourteen years old. Those wonderful wheels were a “godsend” to any prospective robot builder in the 1970s through to the late 1980s, having gone through at least three revisions before, unfortunately, finally becoming permanently unavailable. In any event, MicroTrons entire construction was designed specifically to fit those motorized caster wheels. To that end, Tod designed the basic framework as an equilateral triangle, 23” (584.2mm) to a side and intended to attach to three of those TM20K370 motorized wheels. Later, when Tod found it necessary to include some sort of contact sensing bumper scheme (the blunder bumper impact sensors), he designed an eight-sided figure to hold the impact sensors. The eight-sided figure was intended to attach to the inner triangular framework. This outer hull, or blunder bumper impact sensor frame, was designed such that it would overlap, at some point, each of the three vertices of the triangle for mounting purposes, thus the reasoning for its non-equilateral shape.

MicroTrons inner triangular framework and outer hull (impact sensor frame) were all constructed from 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle stock. The lower inner triangular frame was assembled by bolting it directly to the swivel discs of the motorized caster wheels. The upper inner triangular frame was then added approximately 5” (127mm) above the lower triangle and was necessitated in order to stabilize the “wobble” inherent in the shaft/swivel disc of the motorized wheels. As just noted, the two triangles were separated by 5” (127mm) thus making the total height (distance), from the bottom of the lower triangle to the top of the upper triangle, about 7” (177.8mm). Two eight-sided polygons (referred to by Tod as “non-equilateral octagons”) were then constructed and attached to the lower and upper triangles, thus bringing the total height (distance), from the bottom of the lower polygon to the top of the upper polygon, to about 7.25” (184.15mm).

Given that the motorized caster wheels (TM20K370, TM21K460, etcetera) are no longer available, and have not been for several decades, it would behoove the prospective MicroTron robot builder to search out (or design and build) a suitable replacement motorized wheel and to then modify the original MicroTron design to fit (accomodate) the replacement motorized wheels. All three of MicroTrons wheels were motorized in the original design, with the single front drive wheel also being used for steering. As we will be basically redesigning the drive system to fit currently available wheels and motors, there is no reason why we could not simply use a single drive motor in addition to the steering motor. In fact, there are many possibilities. A few such configurations to consider might be:

1. A single front drive wheel and steering motor with the two rear wheels “free spinning”.

2. Dual rear drive motors with a single “free spinning” front steering motor.
3. Dual rear-drive/differential steering motors with a single “free spinning” front “swivel caster”. A nice set of components which could potentially be used in this configuration might be the Parallax, Inc. Motor Mount & Wheel Kit - Aluminum (#28962) in conjunction with the Parallax, Inc. Caster Wheel Kit Rev. B.

There are many other possibilities such as using omniwheels, mecanum wheels, three wheel steering and so on. In the end, it depends mostly on how close that you want to get to the original MicroTron design. I am currently considering the second option above based on the tentative availability of several dual motorized wheel kits being on the market. These kits range from units specifically designed for robotics/smart car use including several made from electric car window motors through to those designed for use in childrens ride on toy cars (such as the Power Wheels™ brand). A few such kits that come immediately to mind are:

1. Parallax, Inc. Motor Mount & Wheel Kit - Aluminum (#28962) @ $299.00. The aluminum Motor Mount and Wheel Kit is a precision-machined mechanical drive system designed for mobile robotic platforms. The brushed motors are worm-gear driven, and the main drive axle (0.5” dia.) is cradled in a ball bearing assembly for smooth-rolling performance. The included 36-position disk Quadrature Encoders resolve to 144 discrete ticks per tire revolution for precision navigation. Key Features Include: machined 6061 aluminum components for smooth, worry-free performance, 60 lb. payload capacity, compatible with any microcontroller, 144 encoder positions per revolution provide 0.14” of linear travel accuracy, conveniently positioned pre-tapped screw holes for easy mounting, rugged 6” pneumatic tires are suitable for a variety of terrain, smooth-rolling and quiet performance. As of this writing, this is the only and current motorized wheel kit offered by Parallax, Inc. In the past, they have also offered ABS Plastic (rather than, but in addition to, aluminum) versions of their wheel kits, however no such product is currently available. There have also been previous versions of the aluminum version which, in general, is not compatible with the newest and current version.
2. Cytron Power Window Motors w/5" Wheels (Pair) @ ~$62.50. Description: Voltage Rating: 12VDC, Speed (No Load): ~85RPM, Torque: 30Kg.cm, Includes 5" wheels. Everyone loves to build mobile robots with Power Window motors, but the shaft is not standard and difficult to mount a wheel to it. The Power Window Motors w/5" Wheels (Pair) is now readily attached with 5 inches robot wheel together with the coupling/hub. Now, building combat robot should be easy and fun!
3. Generic Childrens Electric Car DIY accessories, includes wires and gearboxes. Intended for construction of a Self-made toy car. Full set of parts for electric kids ride on car. These “generic” Power Wheels™ type kits usually contain two to four 550 or 570 type drive gearboxes/motors, a steering motor, wiring harness, bluetooth remote control, etcetera. These types of sets are perfect for use in constructing a more modern MicroTron robot. Keep in

mind the inverse relationship of speed to torque - the lower the RPM (speed), the higher the torque and we need all of the torque that we can muster. The listed RPM of these kits generally refers to the RPM of the DC motor rather than the final output of the gearbox. I prefer to use those that are rated at no more than 15,000 RPM for the increased torque. Lately, I have been utilizing the 8000 RPM versions in my projects. Previously, I was using the 10,000 RPM versions. Note that if the 23,000 RPM or higher speed versions are used, it will likely be necessary to use two or more to achieve the same results as a single 10,000 RPM (or lower) unit. Do not be afraid to run things a bit on the slow side as it will require quite a lot of torque to move a mass the size of "MicroTron".

4. DFRobot Rubber Wheel 136×24mm & Motor Kit @ ~$125.99. Description: Super quality pack for indoor robots, comes with 12V low noise DC motor @ 146RPM, rubber wheel 136×24mm (pair), two phase hall encoder. The Rubber Wheel & Motor Kit is a quality pack for indoor robots, especially for a home care robot platform, and comes with a 12V low noise DC motor @ 146RPM, encoder and rubber wheel 136×24mm (pair). Motor: The DC motor is a customized high quality, low noise, high torque output motor with optical encoder built-in. The optical encoder gives 663 pulses per rotation which is able to sense 0.54 degree rotation from the shaft. This resolution meets general PID speed control requirements thus making it a great choice for robotics. The sturdy metal casing, and gears is a good choice for a competition robot or in harsh environments where your robot might get hit by objects or people. This motor is widely used in the mobile robot area and some stationary automation devices. The optical encoder is cased in a plastic top which is easily accesible, and with the included cable you can easily connect it to your device. Rubber Wheel: This high quality rubber wheel is formed after testing more than 6 different rubbers on carpet, wood surface, marble surface, glass surface, with proper softness and tire surface design. The dent on the tire plays a good anti-slip effect and provides a firm grasp over the moving surface. This tire has been widely used on HCR mobile robot platforms. Specifications: DC Motor: Model: 28PA51G, Working voltage: 12V, No load RPM (before gearbox): 8000 rpm, No load 68dBA (10cm measurement distance), Gear ratio: 51:1, No load RPM (after gearbox): 146rpm @ 12V, No load current: @ 12V: 0.23A, Stall current: 3.6A, rated torque @ 12V: 10kg.cm (139oz.in), encoder resolution: 13 PPR (663 PPR for gearbox shaft). Dimensions: DC Motor: Size: 123mm x 36mmx 36mm, Weight: 270g, Rubber Wheel: Outer Diameter: 136mm, Inner diameter: 18mm, Wheel Width: 24mm.

Despite the fact that only four types of motor/gearbox combinations are listed above, there really are quite a few options available for gearmotors and wheels. Try to make an informed decision and design your version of MicroTron around that decision. An important point to note is that since we are not using the motorized caster wheels as used in the original design, we could quite easily eliminate the two triangles and the two eight-sided polygons that were originally constructed from the 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle stock. Indeed, that is the whole point of this document in which we will lay out the eight-sided polygon and cut it from a sheet of plywood or aluminum sheeting. The motorized wheels will then be attached directly to the lower eight-sided polygon. In this manner, we have eliminated the need to cut all of those pieces of angle aluminum to size and to cut all of those angles in the resulting pieces which would then have had to be bolted together to form the triangles and the polygons. This not only saves a lot of work but also results in a much more sturdy mainframe.

This document, “FullSize8SidedPolygonAttemptOne.docx”, represents my very first attempt (and failure) to lay out a suitable eight-sided polygon for use in constructing a modern MicroTron robot. My intent was to create a polygon sized as closely as possible to the final dimensions of the original MicroTron robot. Unfortunately, the dimensions of this particular design are incorrect mostly due to my improper mathematical calculations and C.A.D. layout. Although this eight-sided figure (polygon) is certainly close enough for use in building a full-sized MicroTron robot, there is plenty of room for improvement, such as correcting the improper dimensions. I, personally, would not use this version of the eight-sided polygon and, in fact, the only reason for including this information in the archive is so that all of the time and effort that I have expended in creating this component is not wasted.

Allow me to elucidate: As previously stated, Tod designed the MicroTron ("Mike") Robot around the Herbach & Rademan TM20K370 Motorized Wheels and as such, the majority of the robot was constructed from 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle stock. This aluminum angle was used, initially, to create an equilateral triangle 23" (584.2mm) on a side with the angle aluminum pieces being bolted directly to the swivel disc of each of the motorized caster wheels. Two such triangles were needed for stabilization of the “wobbly” motorized wheels. When it came time to add a set of contact sensing bumpers, which Tod referred to as "impact sensors", Tod devised an eight-sided polygon that would overlap, at some point, each vertice of the triangle. Two such polygons were also needed, one for the lower triangle and another for the upper triangle. Each polygon was further supported by two additional aluminum angle braces, thus each eight sided polygon was constructed from ten pieces of 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle. Those ten pieces of angle aluminum were of the following lengths:

Piece Number and Impact Sensor Number	Length of Angle Aluminum	Length of Associated Impact Sensor
1	18.250" (463.550mm)	17.00" (431.80mm)
2	11.000" (279.400mm)	09.25" (234.95mm)
3	10.500" (266.700mm)	07.50" (190.50mm)
4	14.625" (371.475mm)	13.00" (330.20mm)
5	11.750" (298.450mm)	10.00" (254.00mm)
6	14.625" (371.475mm)	13.00" (330.20mm)
7	10.500" (266.700mm)	07.50" (190.50mm)
8	11.000" (279.400mm)	09.25" (234.95mm)
9	08.625" (219.075mm)	***
10	08.625" (219.075mm)	***

It is entirely possible to calculate the exact length of each of the eight sides of the polygon by applying some elementary principles of mathematics. This would require taking into account the angle cuts and the lengths of the angles on each of the eight pieces of angle aluminum that make up the outer hull (eight-sided polygon, see "How To Build A Computer-Controlled Robot" by Tod Loofbourrow for the appropriate angle cuts and dimensions). Note that the impact sensor lengths closely approximate the length of the polygon sides to which they are attached. In reality, the sides of the polygon will be only very slightly larger than the impact sensor attached to it and we can, in theory, save ourselves the time and effort required to calculate these piece sizes by simply utilizing the lengths specified for the impact sensors as the lengths of the mating polygon sides. In my quest to be as precise as possible, I decided to attempt to calculate the polygon side lengths with three SAE digits of precision. My initial (and incorrect) calculations are summarized in the table below:

Piece, Side and Impact Sensor Number	Incorrectly Calculated Length of Polygon Sides	Specified Length of Associated Impact Sensor
1	17.188" (436.5752mm)	17.00" (431.80mm)
2	08.782" (223.0628mm)	09.25" (234.95mm)
3	07.576" (192.4304mm)	07.50" (190.50mm)
4	12.597" (319.9638mm)	13.00" (330.20mm)
5	10.072" (255.8288mm)	10.00" (254.00mm)
6	12.597" (319.9638mm)	13.00" (330.20mm)
7	07.576" (192.4304mm)	07.50" (190.50mm)
8	08.782" (223.0628mm)	09.25" (234.95mm)

Unfortunately, I did not make a note of the mathematical procedures that I utilized to arrive at these numbers quite some months ago. The method was sound but I went awry somewhere along the way and arrived at the figures incorrectly (as is evidenced by some of my calculated sides being shorter than the associated impact sensor). This eight-sided figure (polygon) is certainly close enough for use in building a full-sized MicroTron robot, however, I would not recommend it as there is plenty of room for improvement. One such improvement would be in the correction of the improper calculations of the dimensions. The only real reason for including this information in the archive is so that all of the time and effort that I expended in calculating, simulating and creating this component is not entirely wasted. Allow me to elucidate: As previously stated, Tod designed the MicroTron ("Mike") Robot around the Herbach & Rademan TM20K370 Motorized Wheels. As such, Tod constructed the majority of the robot from 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle stock in a fashion allowing the lower inner frame to be assembled by simply bolting it to the swivels discs of each of the three motorized wheels. This aluminum angle was used, initially, to create an equilateral triangle 23" (584.2mm) on a side with the angle aluminum pieces bolted directly to the swivel disc of each of the motorized caster wheels. When it came time to add a set of contact sensing bumpers, which Tod referred to as "impact sensors", Tod devised an eight-sided polygon that would overlap, at some point, each vertice of the triangle. Those eight pieces of angle aluminum were of the following lengths:

The contents of this document and the accompanying DIRectory (folder), including all files, represents a full-scale implementation of the MicroTron robot Eight-Sided Polygon (referred to by Tod Loofbourrow as a non-equilateral octagon). Unfortunately, the dimensions of this particular design are incorrect mostly due to my improper mathematical calculations and C.A.D. layout. This eight-sided figure (polygon) is certainly close enough for use in building a full-sized MicroTron robot. There is, however, plenty of room for improvement, such as correcting the improper dimensions. I, personally, would not use this version of the eight-sided polygon. In fact, the only reason for including this information in the archive is so that all of the time and effort that I expended in creating this component is not wasted.

.Allow me to elucidate: Tod designed the MicroTron ("Mike") Robot around the Herbach & Rademan TM20K370 Motorized Wheels. As such, Tod constructed the majority of the robot from 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle stock. This aluminum angle was used, initially, to create an equilateral triangle 23" (584.2mm) on a side with the angle aluminum pieces bolted directly to the swivel disc of each of the motorized caster wheels. When it came time to add a set of contact sensing bumpers, which Tod referred to as "impact sensors", Tod devised an eight-sided polygon that would overlap, at some point, each vertice of the triangle. Those eight pieces of angle aluminum were of the following lengths:

Conclusion

Text
The contents of this DIRectory (folder) are a full-scale representation of the MicroTron robot Eight-Sided Polygon (referred to by Tod Loofbourrow as a non-equilateral octagon). Unfortunately, the dimensions of this particular design are incorrect. Certainly, this eight-sided figure (polygon) is close enough to build a full-sized MicroTron, there is much room for improvement. Allow me to elucidate: Tod designed the MicroTron ("Mike") Robot around the Herbach & Rademan TM20K370 Motorized Wheels. As such, Tod constructed the majority of the robot from 1"x1"x.125" (25.4mm x 25.4mm x 3.175mm) aluminum angle stock. This aluminum angle was used, initially, to create an equilateral triangle 23" (584.2mm) on a side with the angle aluminum pieces bolted directly to the swivel disc of each of the motorized caster wheels. When it came time to add a set of contact sensing bumpers, which Tod referred to as "impact sensors", Tod devised an eight-sided polygon that would overlap, at some point, each vertice of the triangle. Those eight pieces of angle aluminum were of the following lengths:
1: 18.250" (463.550mm)
2: 11.000" (279.400mm)
3: 10.500" (266.700mm)
4: 14.625" (371.475mm)
5: 11.750" (298.450mm)
6: 14.625" (371.475mm)
7: 10.500" (266.700mm)
8: 11.000" (279.400mm)
There were also two additional "brace" pieces, however, they are irrelevant to the current discussion. These were of the following lengths:
9: 8.625" (219.075mm)
10: 8.625" (219.075mm)
Each of the above listed pieces (one through eight) had specific angles cut on each end such that they could be assembled into the proper eight-sided polygon. Once the polygon had been constructed and attached to the 23" (584.2mm) motorized triangular inner frame, the impact sensors were then assembled and added. The impact sensor lengths were shorter than the initial lengths of the sides of the eight-sided frame and were actually slightly shorter than the sides to which they were to be attached. The impact sensor lengths were given as:
1: 17.00" (431.80mm)
2: 9.25" (234.95mm)
3: 7.50" (190.50mm)
4: 13.00" (330.20mm)
5: 10.00" (254.00mm)
6: 13.00" (330.20mm)
7: 7.50" (190.50mm)
8: 9.25" (234.95mm)

You would, of course, be forgiven for assuming that the lengths listed above for the impact sensors would also be the lengths of the sides of the polygon. Indeed, they are close enough in practice. However, by application of some basic mathematics, I was able to determine the actual lengths of the sides of the polygon to be:
1: 17.188" (431.80mm)
2: 8.782" (234.95mm)
3: 7.576" (190.50mm)
4: 12.597" (330.20mm)
5: 10.072" (254.00mm)
6: 12.597" (330.20mm)
7: 7.576" (190.50mm)
8: 8.782" (234.95mm)
In order to verify my calculations, I modeled the angle aluminum pieces in C.A.D. software and assembled the pieces on-screen. All of my calculations lined up precisely to the model with the exception of polygon side one. Polygon side one was calculated as 17.188" (mm), however, the initial C.A.D. model indicated that the actual length should be 17.485 (mm). After minor tweaking, the C.A.D. model indicated that the precise length of polygon side one should be 17.484" (mm).

At this point, you may be wondering as to the purpose of creating this eeight sided polygon. The answer is that most of the framework that Tod designed was created specifically for use with the TM20K370 motorized caster wheels. Since these wheels are no longer available and alternatives must be used, then there is no need to fool around with constructing the triangular portion of the mainframe. Two of the eight-sided polygon pieces could simply be joined together with about 5" (mm) of spacing between them. Then, it should be a simple matter to attach whatever motorized wheels that you have to hand to the bottom of the structure. Note that the cutout in the centermost part of the eight sided figure is intended to be used for the battery cage and should support all common 100Ah, 12V batteries. You would likely not need the cutout in the top piece of the mainframe since the battery sits through the hole in the center of the bottom piece, resting comfortably in the battery cage and riding approximately 2" above ground level.

Including this particular set of files in this archive negates the need of designing a TM20K370 motorized wheel, which is the actual focus of this project. My reasons for including it is that it just happens to be a very useful method of building a full-scale MicroTron robot Mainframe utilizing moderm motors and wheels.

-to be completed later - need a nap before work (3rd Shift)

-The R.A.T.

Full Size Eight-sided Polygon, Attempt One

Parallax, Inc. Motor Mount & Wheel Kit - Aluminum (#28962) @ $299.00
The aluminum Motor Mount and Wheel Kit is a precision-machined mechanical drive system designed for mobile robotic platforms. The brushed motors are worm-gear driven, and the main drive axle (0.5” dia.) is cradled in a ball bearing assembly for smooth-rolling performance. The included 36-position disk Quadrature Encoders resolve to 144 discrete ticks per tire revolution for precision navigation. Key Features include: Machined 6061 aluminum components for smooth, worry-free performance, 60 lb. payload capacity, Compatible with any microcontroller, 144 encoder positions per revolution provide 0.14” of linear travel accuracy, Conveniently positioned pre-tapped screw holes for easy mounting, Rugged 6” pneumatic tires are suitable for a variety of terrain, Smooth-rolling and quiet performance.