Enhancing Mechatronic Education with a Low-cost Conversion of a First Generation DaNI Robot to a Second Generation Platform

Aidan F. Browne, Christopher Benfield, Matthew Calvin
The University of North Carolina at Charlotte

Abstract

National Instruments' original DaNI platform was a successful solution for prototyping of mechatronics systems, but had difficulty steering due to its four wheel design, high center of gravity and short wheelbase. The next generation robot, DaNI 2.0, was greatly improved with a three-wheel platform, updated sbRIO, extended wheelbase and an omni wheel for improved steering. It would be a substantial cost to replace a fleet of DaNI 1.0s with 2.0s. This paper describes a methodology developed by students to convert a 1.0 platform to a 2.0 equivalent. The approach reconfigures the structure, recycles most of the parts, and adds a few additional parts for less than $30. The 1.5 platform has all of the functionality of a 2.0 platform, except for the upgraded sbRIO board. Future work will retrofit with a myRIO to significantly improve processing and memory performance, and add wireless capability.

Keywords

DaNI, Mechatronics, National Instruments, retrofit

Introduction

National Instruments' DaNI robotic platform has been a successful solution for prototyping of mechatronics system. This platform, shown in Figure 1, had difficulty steering due to its four drive wheel design, high center of gravity and short wheel base. These issues limited the maneuverability of the DaNI 1.0 platform due to the presence of wheel spin and sliding; these dynamics made algorithm implementation difficult. The high center of gravity and short wheelbase of the DaNI 1.0 platform made it cumbersome to have the robot traverse an obstacle course, due to its often getting stuck or tipping.

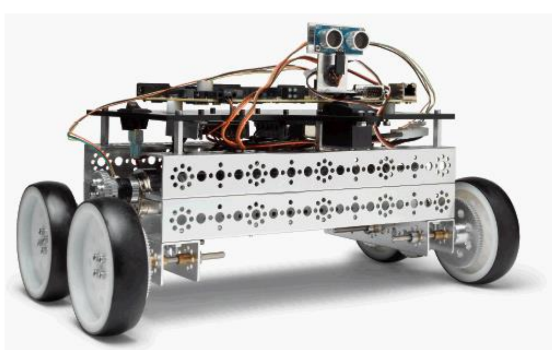

Figure 1: DaNI Robot 1.0 [1]

In 2011, National Instruments and Pitsco released the DaNI 2.0, shown in Figure 2. It was a greatly improved three-wheeled platform along with an updated sbRIO, extended wheelbase and an omni wheel for improved steering. The DaNI 2.0 also went to two drive wheels allowing for improved steering while maintaining the platform's yaw rotation capabilities. Converting DaNI 1.0 platforms to a 2.0 equivalent can be done with a few additional parts, including six bolts, six nuts, six standoffs, and an omni wheel, for less than $30. We have named the converted platform the DaNI 1.5; it has equivalent functionality to a 2.0, except for the upgraded sbRIO board. The DaNI 1.5 still has full capability of add-ons such as an accelerometer or infrared sensors.

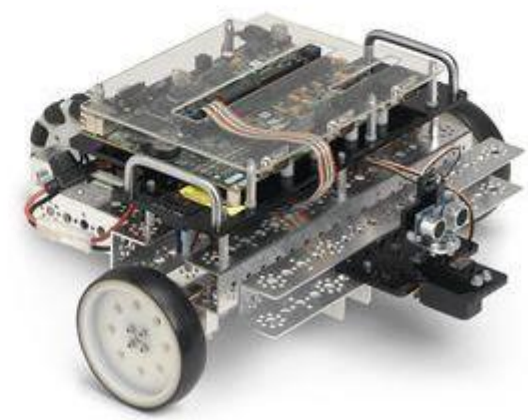

Figure 2: DaNI Robot 2.0 [2]

The complete conversion was made by students using only three common hand tools: 7/64 hex wrench, 3/32 hex wrench, and a small pair of pliers.

DaNI Conversion Parts

There are a few inexpensive parts required for the DaNI Robot, as detailed in Table I. The largest cost of the conversion was the TETRIX Omni wheel pack from Pitsco[3].

Table I – Parts List

Quantity	Item	Approximate cost
6	1.5 inch socket head cap screws	$2.50
6	hex nuts #6-32	$0.20
6	nylon 6/6 unthreaded spacers, #6 screw size 0.25 inch OD, 0.875 inch length	$0.60
1	TETRIX Omni wheel pack	$25.00

The spacers and bolts were chosen at the length so that the DaNI robot would sit approximately parallel to the surface below the robot. This was done to increase the adaptability of the converted robot, such as adding an accelerometer to the front of the robot.

DaNI 1.0 Disassembly

Disassembly of the DaNI 1.0 to the base components was required to reconfigure to a DaNI 2.0 equivalent. This entailed the removal of the complete drive assembly including the idler gear and drive motors.

Disconnection of the circuit board was required prior to its removal. Figure 3 shows the location of wiring connections that were disconnected prior to removal of the circuit board from the chassis (A, B). All disconnection of wires, with the exception of the accelerometer, were completed at the component end of the wiring and not the board.

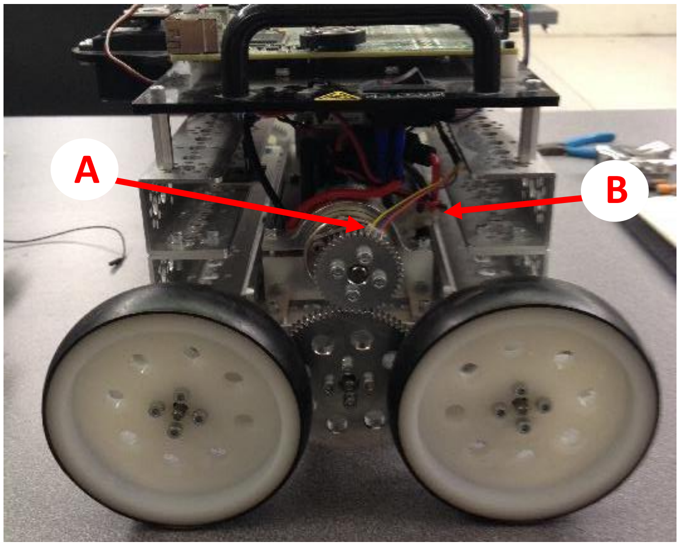

Figure 3: Electrical connectors

Wires to the following components were then disconnected: the drive motor encoders (C), the battery pack (D), and the accelerometer between the circuit board and the sensor. The location of the accelerometer (E) and the four wires connecting it (F) are visible in Figure 4. Encoder and motor drive wires were labeled to ensure that they were returned to the proper side when reassembled. This step was necessary to ensure the robot would respond properly to inputs.

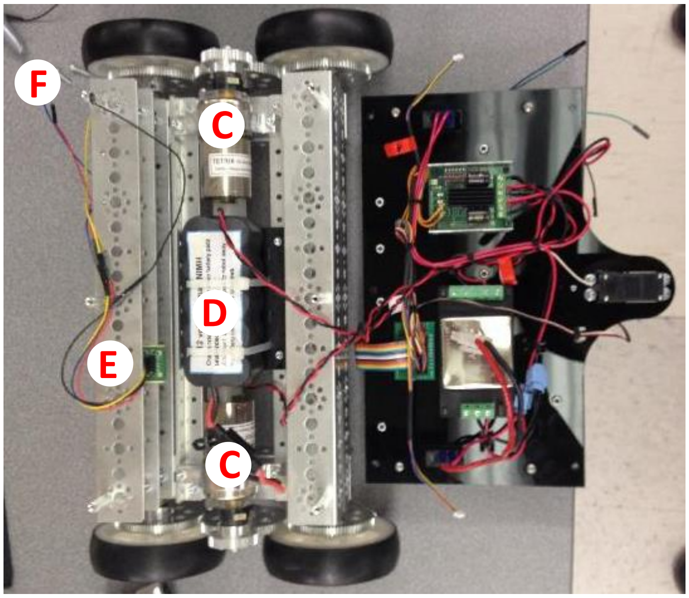

Figure 4: DaNI with board removed

With the above disconnections complete, the 6 screws that retain the circuit board and the Lexan plate were removed. Removal of the circuit board was the next step in disassembly. Figure 4 shows the DaNI 1.0 robot with the circuit board removed. The battery, drive motors and accelerometer are visible. Next, the battery pack (D) and drive motors (C) were removed. The accelerometer (E) was left in place. The motor wires were disconnected from the drive motors themselves and not from the board.

The drive gears were removed from the motors by unscrewing the four bolts that held them to the shaft collar. The shaft collars remained attached to the drive motors. Two of the wheels were removed from their axle assemblies, and were saved for reuse during reassembly.

Next, the drive wheel and chassis were disassembled. Figure 5 shows the DaNI 1.0 with the battery and drive motors removed. The two angled pieces (G) that held the battery pack and served as a spacer for the drive motors were removed and discarded. The chassis was then placed upside down to allow the drive wheels and the idler gears to be removed. After the wheels were removed, the channels that held the wheels in place (H) were removed. Lastly, as shown in Figure 6, the two sections of channel were separated. The section containing the risers for the circuit board was left connected.

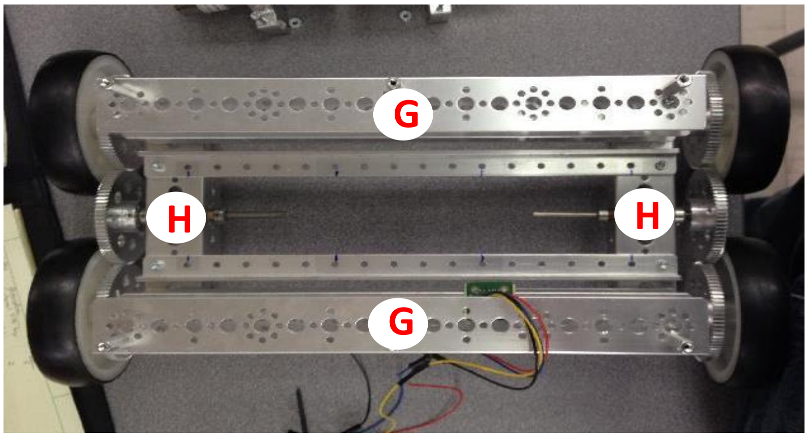

Figure 5: DaNI chassis

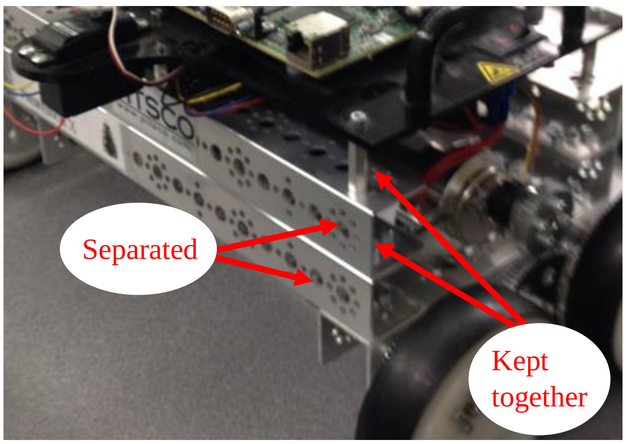

Figure 6: DaNI front

DaNI 1.5 Assembly

Conversion to DaNI 1.5 required the purchase of 4 new components. The first were Omni wheels. The wheels used for conversion were 4-inch TETRIX® Omni Wheels from Pitsco (#W36466)[3]. The other components were the stand-off spacers, bolts and nuts.

To begin chassis reassembly the frame was reconfigured as shown in Figure 7. The c-channels that had the spacers for the circuit board were reattached to the sections that previously housed the drive and idler wheel assemblies; the orientation was changed from the open end of the channel pointing downward to the open end of the channel now facing inboard. The ends of the chassis were set flush with no overhanging portions. Each corner was secured with two screws and lock nuts.

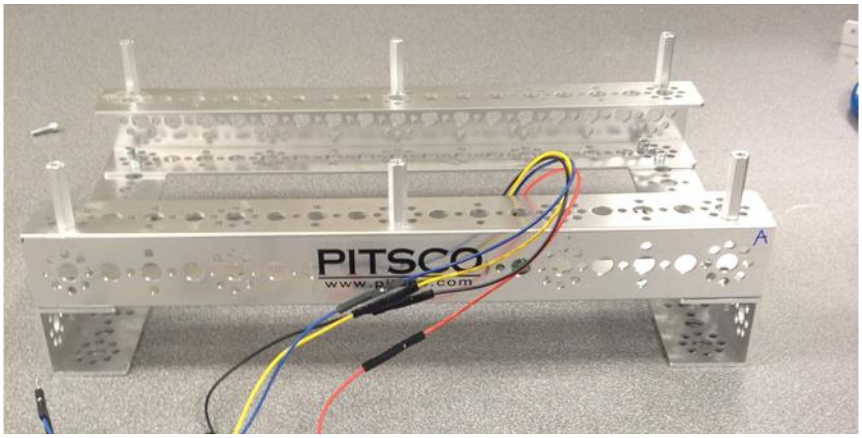

Figure 7: Chassis reassembly

Next, the drive motor assemblies were rotated 180 degrees in their mounts so that the encoder plug faced the flat side of the mounts. Figure 8 shows the motors rotated to the correct orientation.

Figure 8: Drive motor orientation

The drive motor assemblies on the bottom of the chassis were reassembled and located as shown in Figure 9. This was necessary to facilitate the smallest footprint for the robot. The arrow indicates the direction of the robot front.

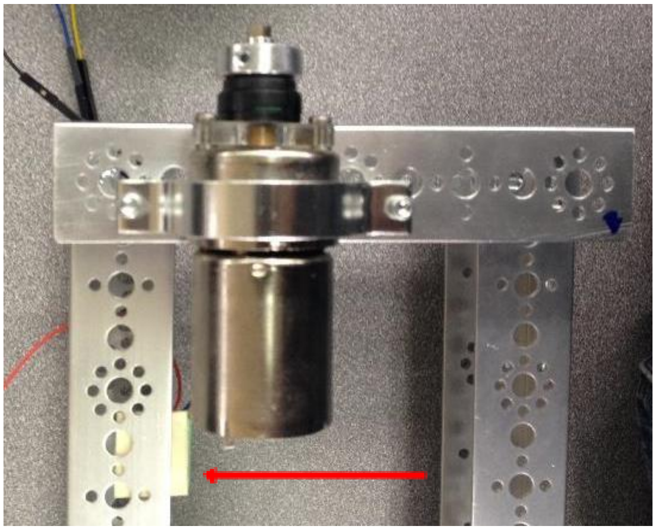

Figure 9: Drive motor reinstalled

The chassis rails that hold the battery and omni-directional wheel were reinstalled. The open end of the channels were orientated downward and were spaced 1.25 inches apart as shown in Figure 10. The rails were attached with six standoff spacers between the chassis drive motor assembly and the rails. The front bolts were placed in the rear most holes on the front chassis rail as shown in Figure 11.

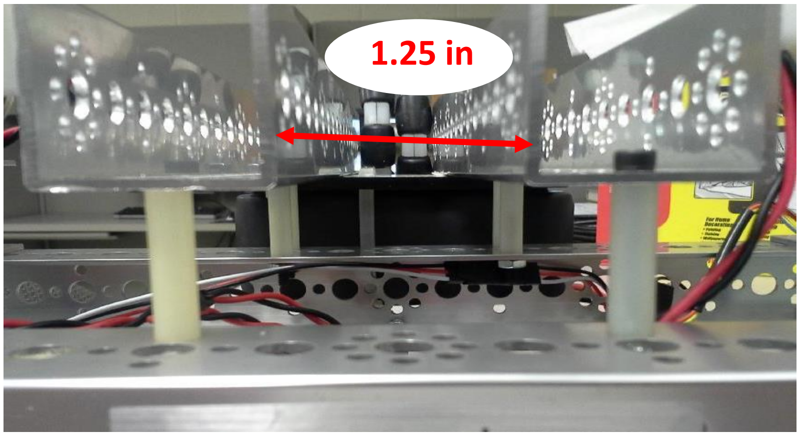

Figure 10: Chassis rail spacers

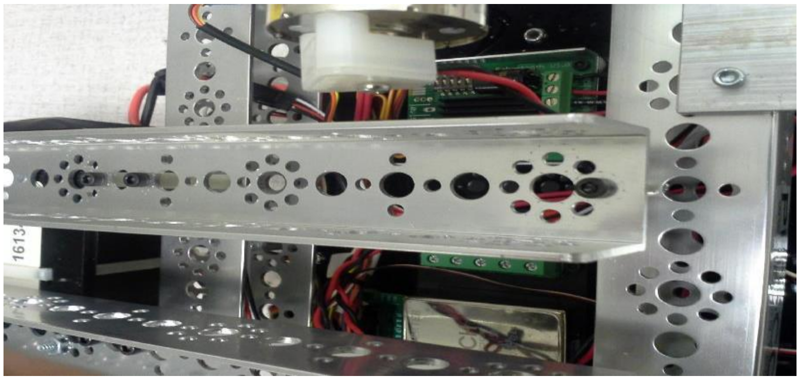

Figure 11: Rail to chassis bolt location

With the rails installed the battery pack was reinstalled along the rear section of the trailing wheel rails. The battery pack was attached with 2 bolts on one of the rails. The other side was not fastened.

Figure 12: Battery pack

The subsequent step was the installation of omni-directional wheels. To adapt the wheel for use, one of the idle gear axles (J), two of the bronze bushings (K), and two of the axle hubs that attached the wheels (L) were needed. The outer two hubs were placed in the last hole of the trailing rails on the outside channel. The two bronze bushings were placed on the inner channel. The omni-directional wheel was then placed between the two channels and the axle slid in and locked in place. Figure 13 shows the rear axle emplaced.

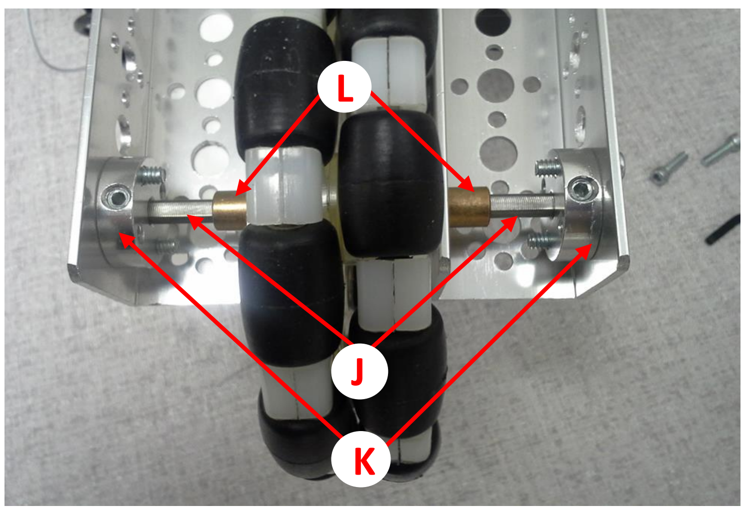

Figure 13: Omni-directional wheel

The circuit board was then reinstalled by replacing the 6 bolts that were removed in disassembly. The motor wires were reinstalled ensuring that they were returned to their appropriate sides. Due to limited length, the wires for the encoders needed to be run through the lower channels as shown in Figure 14.

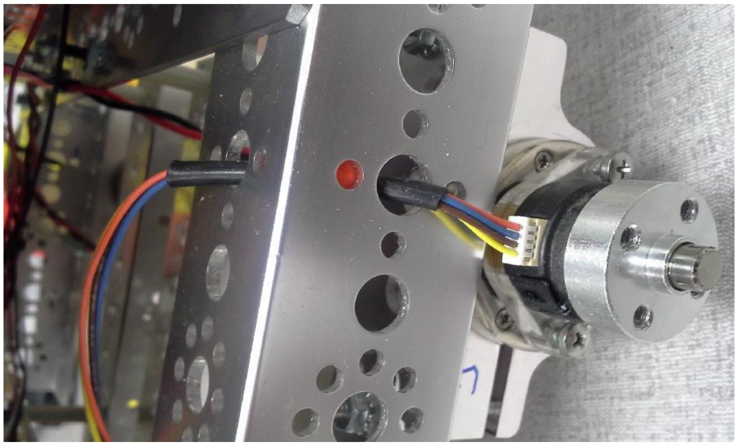

Figure 14: Encoder wire routing

The final step was reinstalling the two forward wheels by replacing the four bolts that attach the wheels to the hubs. Figure 15 shows the completed DaNI conversion.

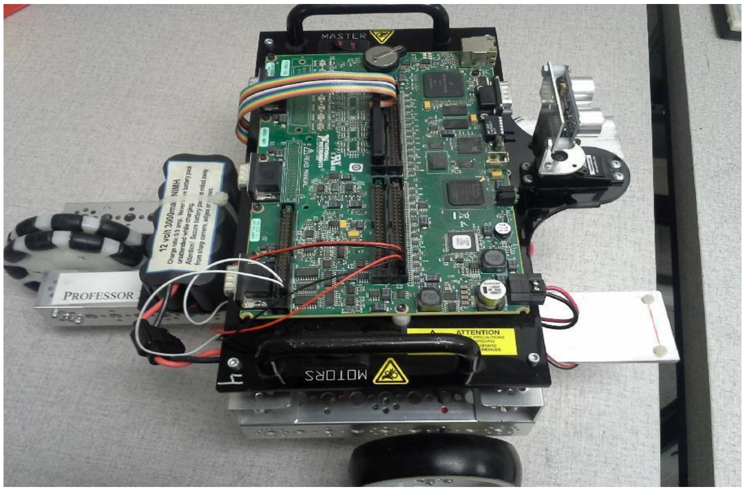

Figure 15: DaNI 1.5 assembly complete

Conclusion

Fully converted DaNI 1.5 robots possess the advantages in maneuverability of the DaNI 2.0. The DaNI 1.5 models were tested by navigating an obstacle course consisting of 90 degree turns, elevation changes, and obstacles that were designed for the DaNI[4]. The converted DaNI 1.5 successfully completed the obstacle course on several test runs. The LabVIEW code used was for the DaNI 2.0, but the version 1.0 robotics tool kit was selected since the control board was not upgraded. In conclusion, it was shown that it is possible to successfully convert a DaNI 1.0 to a DaNI 2.0 functional equivalent at a low cost.

References

1 Mahmoudian, N. (2012, August 16). DaNi Robot Educational research Platform. Retrieved December 1, 2014, from file:///D:/Downloads/TS8900 DaNI Robots (1).pdf

2 "NI LabVIEW Robotics Starter Kit for Prototyping." National Instruments. Accessed December 1, 2014.

3 TETRIX® MAX Omni Wheel Packs. Accessed December 7, 2014. http://www.pitsco.com/TETRIX_Omni_Wheel_Packs.

4 Conrad, J. and Kerry, M., "LabVIEW Robotics Starter Kit (DaNI) Lab Exercises," Session TS5040, NIWeek 2011, Austin, TX, August 1-3, 2011.

Aidan F. Browne

Dr. Browne is an Assistant Professor at The University of North Carolina at Charlotte. His current research areas are mechatronics, mission critical operations, instrumentation and controls. His core courses are an undergraduate three-semester embedded controller practicum and a graduate mechatronics course. He mentors a Senior Design team that competes in the NASA Robotic Mining Competition. He received his B.S. from Vanderbilt University and his M.S. and Ph.D. in Biomedical Engineering from the University of Connecticut. Dr. Browne serves as the Chair of the Engineering Technology Division of the Southeastern Section of ASEE; he also does extensive volunteer work for the FIRST Foundation.

Christopher Benfield

Mr. Benfield is a graduate student at The University of North Carolina at Charlotte. He is currently pursuing a Master of Science degree in the Applied Energy and Electromechanical Systems program. He received his B.S. in Mechanical Engineering Technology from UNC Charlotte. He is employed by the University and assists in the design and implementation of instrumentation and control laboratory teaching aids.

Matthew Calvin

Mr. Calvin is a graduate student at The University of North Carolina at Charlotte. He is currently pursuing a Master of Science degree in the Applied Energy and Electromechanical Systems program. He received his B.S. in Mechanical Engineering Technology from UNC Charlotte. He is a graduate assistant in the Department of Electrical and Computer Engineering.