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SERVO MAGAZINE

FOR THE ROBOT INNOVATOR

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you then need to get a separate 12V power supply which can be both expensive and bulky.

The iNDi 16x4 Pro Charge has both 110V AC and 12V DC inlets so that you can use it both indoors with the linecord provided or outdoors with the separate 12V leads.

I purchased three of these chargers in the summer of 2006 for use at a summer "Combat Robotics" camp I was teaching.

They will automatically detect cell type and will charge from 1-15 cells (1.2 to 18V packs) at an adjustable 0.5-5.5A rate. They will also discharge a pack at up to 4A.

One of the three chargers ordered stopped working shortly after receipt but was promptly replaced by the manufacturer. All three also gave off a strong smell of hot oil the first time they were used. The fan is also rather noisy.

They have proven simple to use and reliable. They are very quick to set up, come with all the required leads, and the high charge rate has proven very useful to quickly recharge the NiMH GP2000 18V packs used in the robots. SV

RioBotz COMBOT TUTORIAL SUMMARIZED: Design Fundamentals – P2

● Original Text by Professor Marco Antonio Meggiolaro, Summarized by Kevin M. Berry

Professor Marco Antonio Meggiolaro of the Pontifical Catholic University of Rio De Janeiro, Brazil, recently translated his popular book *The RioBotz Combot Tutorial*, into English. Last month, *SERVO* summarized the first part of a key chapter "Design Fundamentals." This month, we continue the series with the second part of this chapter. Marco's book is available free for download at **www.riobotz.com.br/en/tutorial.html**. All information here is provided courtesy of Professor Meggiolaro and RioBotz.

Beginning the Design

Once you've decided on the general configuration of your bot (disk spinner, drum, flipper, etc.), it's time to start allocating the component's weight. A good rule of thumb is the 30-30-25-15 rule shown in **Table 1**. This was created by Grant Imahara for his book *Kickin' Bot: An Illustrated Guide to Building Combat Robots*. Riobotz refines this rule a bit, as shown in the two righthand columns.

The second rule of thumb is KISS: Keep It Simple, Stupid. Sketch it up in CAD, PowerPoint, or by hand on graph paper. Play around with lots of design options, getting the whole team involved. Remember to place fragile items like speed controllers deep inside the machine. Keep everything compact; space costs weight. Also keep in mind the need to repair items in a hurry during an event, so some space around connections is helpful.

TABLE 1

All material used with permission of RioBotz, Marco Antonio Meggiolaro.

SYSTEM	GRANT'S GENERAL RULE	FOUR WHEEL DRUM BOTS	TWO WHEEL DRUM BOTS
• Drive System (Motors, Transmission, Wheels)	30%	20%	15%
• Weapon System (Weapon, Motor, Transmission)	30%	35%	35%
• Structure and Armor	25%	30%	40%
• Batteries and Electronics	15%	15%	10%

Calculations

Professor Meggiolaro recommends performing some level of stress analysis during the design phase. While this is a valid point, many builders just aren't able to go to that extreme. In Chapter 6 of his book, he goes into extensive detail (65 pages!) on calculating various factors about your bot. Another tip is to use tables gained from builder's experience such as the one shown in Part 1 of this article on weapon shaft thicknesses.

Optimization

Combat robots are born overweight, and seem to get heavier after that. This may require a complete redesign or applying some optimization techniques to lose weight, improve strength, or (hopefully) both.

Optimizing the shape is one approach. Taking a solid disk and removing material without removing strength is a good example. One key factor in the Moment Of Inertia (MOI) of a disk is the mass at any given radius. This means that metal removed near the hub doesn't count as much towards MOI as metal near the edge. Thin spokes aren't as strong as thick ones, so a number of smaller holes may be better than a few big ones. Think of a honeycomb, web design, or a truss. Two good examples are shown in **Photos 1** and **2**.

There is a lot more help on this topic in the book (about 3-1/2 pages worth) and all of it is worth reading.

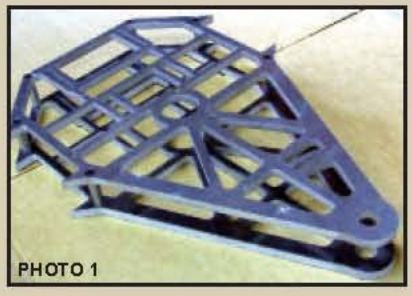


PHOTO 1

PHOTO 2

Building and Testing

Full scale models are another very helpful building step. Components can be mocked up (before spending money) from PDF or CAD drawings. Design can take up to 60% of the total development time, so make it count. Once you've modeled the bot and are ready to cut metal, "measure twice, cut once" is the rule.

Testing is often short changed or overlooked. According to Carlo Bertocchini's Law, "Finish your robot before you come to the competition." Often bots are finished just before (or at!) a competition, leaving no time for testing. Many things can go wrong if the bot doesn't have sufficient drive time before competing. This leads nicely to Show Master Dave Calkin's main advice: LTFD or "Learn To Freakin' Drive!" Drive a lot. Hundreds of hours, not just a few. Good driving wins matches.

Structures

There are three main types of robot structure: trussed, integrated, and unibody. Trussed robots are built using bars, bolted or welded together, resulting in a very rigid and light structure. The armor is usually made out of plates attached to the bars. They are a fast type to build, and are easy to work with during events. The plates (and possibly truss members) can be removed and replaced with spares. The greatest disadvantage is the welded joints which can be weak points. Armor plates can also be ripped off during fights (**Photo 3**).

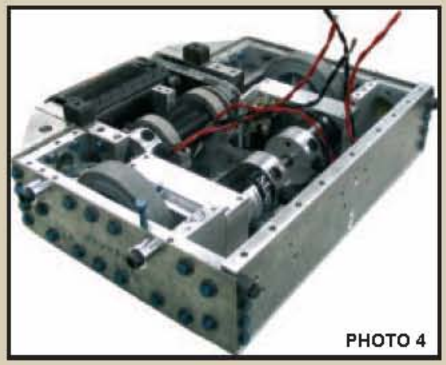
Integrated robots receive their name because the structure and armor are integrated into a single structure using screws or welds. The armor plates are also in the structure. Building this type of bot is harder, but they can be very compact and strong (**Photo 4**).

Unibody robots have their structure milled out of a solid block of material. Through milling, the sides, bottom, and pockets for components are created. No welds or screws are needed except for installing the top. These are the lightest robots, and can be the most damage resistant. However, you can lose more than 80% of the material in the carving process, not to mention the amount of time spent to do this. Another downside is that a damaged structure can't be replaced (**Photo 5**).

Another way to make unibody robots is through molding materials such as composites like carbon fiber or Kevlar. These are not very popular because of the expense, difficulty, and expertise needed.

Armor

Like structures, armor types come in three flavors: traditional, ablative, and reactive. Traditional armor plates are usually made out of tough, hard materials that try to absorb and transmit impact energy. Hardness causes damage to the opponent's weapons, while toughness resists damage. This can be achieved using a composite type armor, as well as the typical metal plates. Depending on the materials,



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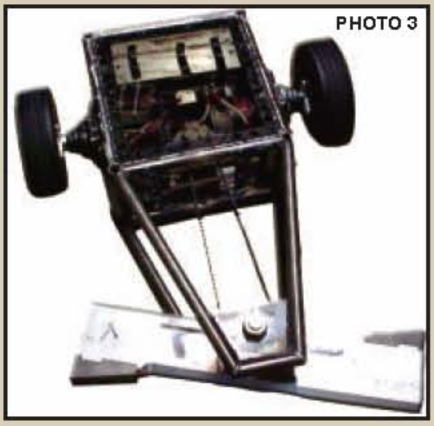

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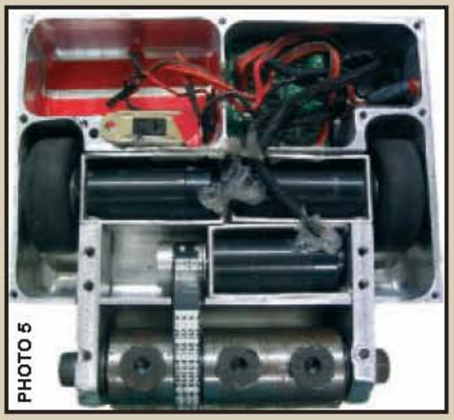

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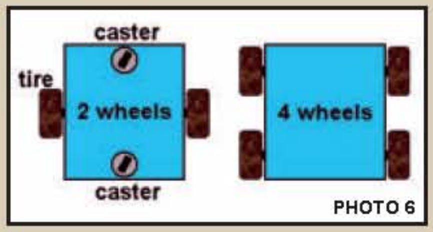

PHOTO 6

traditional armor can emerge from a tough battle with just cosmetic damage.

Ablative armor is designed to negate damage by being damaged! Ablation is the removal of material from vaporizing or chipping. The materials are tough, but with low hardness. Ablative plates are efficient at dissipating energy, transmitting less of an impact to the rest of the bot compared to traditional armor. They work well against blunt spinners. They also can be effective against drum bots, whose typically small teeth eat chunks out of the armor instead of launching the robot. Thick wooden plates can work as ablative armor, however, they result in a lot of visible damage that can cost points. Make sure the judges know your armor is supposed to ablate. Another disadvantage is that it has to be changed frequently.

Reactive armor, as the name implies, reacts against blows. One example is rubber layered metal sandwiches. This works as a shock mounted armor, dissipating energy within the armor itself. A number of reactive types (such as the explosive type found on military tanks) or high potential capacitive discharge types are ruled out by most event's tech regs.

Drive Systems

Completing our trio of threes, there are three typical types of drive systems: treads, legs, and wheels. Tank-style treads give excellent traction and are difficult to high-center. However, they waste a lot of energy when turning and can be slow during turns. Treads are also prone to getting knocked off. They do show well, and are quite fun to drive.

Legs have several disadvantages. They are complex to build and control, and usually not sturdy enough to survive combat. They also raise the center of gravity of the bot, leaving them prone to tipping. The advantage is that most events give a large weight allowance — up to 100% — for true walkers (as opposed to shufflers). In the very rare event where the bot is off-road or on a very uneven surface, legged walkers might show an advantage.

Wheeled bots are the overwhelming design in combat today. Wheel types include pneumatic, (often foam filled), solid, or foam (typically used in smaller bots).

Steering

Two main types of steering are used (Yep, breaking our string of threes). Ackerman steering — common to automobiles — uses fixed drive on two wheels with a smaller motor for steering. This is a very effective system for high speeds, allowing straight driving. Turning in tight quarters can require the "back and fill" technique, leaving it vulnerable to attack.

Tank-style steering is much more popular. Each side — no matter how many wheels — is driven separately. This means to go straight, each must have identical speed which is often difficult to calibrate. Turning is accomplished by having one side at a different speed, or even running in the opposite direction. This allows for very maneuverable robots.

Tank drive bots usually use two or four driven wheels. With two wheels, a lot of weight can be saved. Another form of support is usually implemented, like a caster, ball transfer, or slide. In this design, the wheels work best if they're near the center of gravity for traction and quick turning. If a secondary support is not used and if the wheels are off the center of gravity, the bot is a "front dragger" or "rear dragger" which fits nicely with an offensive or defensive wedge design (**Photo 6**).

Multi Wheel Drive

Often, all four (or more) wheels are driven, making the bot easier to drive straight. This also allows redundancy against damage. A few robots use six or even eight wheels. While being very stable, these do suffer from turning friction problems like a tank tread.

Professor Marco has a nice dissertation on the theory of c.g. versus drive wheel placement, which is worth reading in the book.

Another major design factor is invertibility. This affects the drive system — among other things — because the wheels might need to be greater in diameter than the thickness of the structure. Another solution is to have an "SRiMech" or Self Righting Mechanism. This can be a hoop, pole, or active element to flip the bot back over. This includes wedges or spikes on any flat sides of the bot, so it can't get balanced on a side or end.

Chapter 2 concludes with a long section on tools and equipment, again worth a read.

This short summary covered 21 pages of dense and fascinating material. To get the whole knowledge base, join the over 4,000 people who've downloaded the tutorial so far.

Look for summaries of other chapters on other topics in future editions of *SERVO*'s Combat Zone. SV