

Pitzer Consulting Designs and Builds a Super Human Exoskeleton Using Pro/ENGINEER®

Mr Robot-o created on a shoestrings budget, wins 2nd place in competition

Pitzer Consulting, El Segundo, California

Pitzer Consulting is a machine design firm that specializes in developing better products by leveraging cutting-edge simulation. Pitzer's Team Raptor, led by brothers Chuck and Bob Pitzer, specializes in competitive robotics, and has entered numerous combat robotics competitions including BattleBots.

"It started out as a hobby, as fun," says Chuck Pitzer, "but then it turned into something where we were making a little bit of money. It allowed us to do something we really like to do, which is build these machines that go out and fight each other."

In 2004, another competitive opportunity arose, albeit a less violent one: The team was tasked with building a "strong man exoskeleton"—that is, a hard suit that fits over the body and magnifies human strength. Competition rules stated that entrants' exoskeleton prototypes be able to lift a 1600-pound weight to a height of three feet.

The Challenge: Time and Cost Constraints

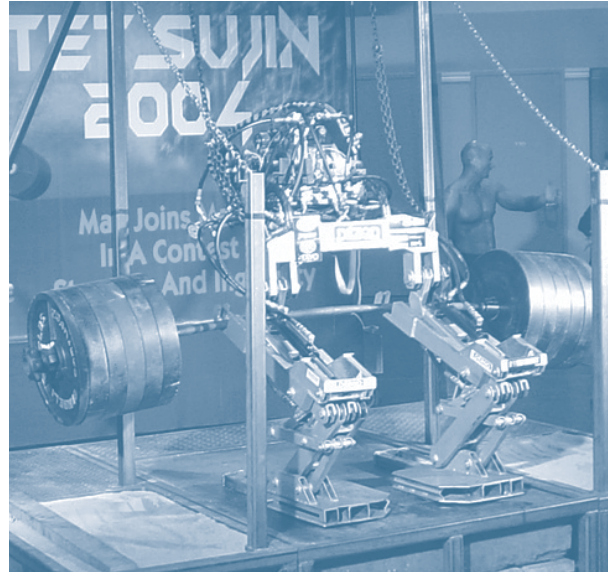
Time is always at a premium because Team Raptor is a lean group without the luxury of big-company resources; Chuck Pitzer was doing all design, simulation and behavior modeling simultaneously on his desktop. Another challenge was cost. "You can always build something," he says, but it just takes money, and a lot of time it's funded out of your own pocket. You need to temper yourself to make sure your costs don't get out of hand."

The Solution: Pro/ENGINEER Design and Simulation

Saving time and cost on product design and manufacture is at the heart of PTC's Pro/ENGINEER 3D product design solution. So Team Raptor's easy choice was Pro/ENGINEER to help develop its exoskeleton design. Pro/ENGINEER helped save design time and cost," he says. "Our exoskeleton had to be reliable, with no failures." With Pro/ENGINEER and its companion simulation modules, Structural and Thermal, and Mechanism Design, Pitzer was confident that he had the right tools to develop a working prototype. "These are all proven solutions," he says. "They've been around a while, and they're very refined. You don't have to play around with second-rate tools. You've got the real deal."

The Results: A Strong Showing

Pitzer is proud of what he and his team accomplished on a shoe-string budget of less than \$6,000. Team Raptor's Pro/ENGINEER-designed exoskeleton garnered second-place honors at the competition. "We knew that within our budget parameters, we couldn't make the machine walk or anything sophisticated like that," he says. "So we went with something simple, with basic components to do the weight-lifting tasks that the competition called for." And, referring to the sleek, futuristic look of the exoskeleton, he adds with a smile, "And we looked good doing it."



Team Raptor's anthropomorphic exoskeleton designed entry "Pinch Point" with Pro/ENGINEER, squats prior to its next lift.

"I've seen the struggles that other people go through with competitive [CAD/CAE] systems. Everybody tries to mimic Pro/ENGINEER Simulation capabilities, but they just can't get there."

—Chuck Pitzer,
Pitzer Consulting

Epilogue: Gearing Up For Another Competition

Team Raptor was so encouraged by their impressive showing that they signed up for an upcoming 2006 exoskeleton competition called "RoboOlympics." The team is already at work on a new, more advanced exoskeleton design, which has a look and feel that's reminiscent of the bipedal walkers of Star Wars fame.

The RoboOlympics criteria for exoskeleton activities are higher: a prototype must be able to not only lift a weight, but also to walk, walk up stairs, and manipulate its cargo. To achieve these headier objectives, Team Raptor turned once again to Pro/ENGINEER simulation solutions.

Kinematic and Dynamic Motion Simulation

Of particular value was Pro/ENGINEER's kinematic and dynamic motion simulation solution, which ensured that the exoskeleton could accomplish its given tasks. "Our machine had to stand up and down, and lift payload in a certain range of motion within capabilities of our hydraulic actuators and other components," Pitzer says. "I would create this motion simulation in Mechanism and go in and change geometry within the design, then just keep iterating and optimizing until I got the behavior I was looking for."

One System-Level, System-Wide Simulation

Pitzer says that the tight integration of Pro/ENGINEER, mechanisms design and structural simulation capabilities was a valuable time saver. "It means we don't have to jump around between software programs," he says. All of the team's design activities can be accomplished within the Pro/ENGINEER solution, without having to exit the program in search of another tool or waste time with data translation or recreating and preparing data for analysis.

"I can optimize iteratively in real time and see how it affects the system, all within Pro/ENGINEER," Pitzer says. "I have motion simulation set up within Pro/ENGINEER and build on top of that. There are different tools that tie into each other into one larger, system-level, system-wide simulation."

Avoiding Failures, Modifying Behavior

Pitzer is impressed by Pro/ENGINEER Structural and Thermal Simulation's ability to help anticipate and remedy design and engineering problems before the project gets to the more costly manufacturing phase. "Whenever you design a machine like this, you want to make sure there are no structural failures," he says. "I use Structural and Thermal to answer specific questions about linkages."

"For instance, I want to make sure that a leg linkage won't buckle and hurt me or someone around me. You don't want to be sitting in the thing and break a linkage or something because you couldn't do the proper homework and analysis. With Structural and Thermal, I can quickly make changes and test out a bunch of iterations."

A key advantage, Pitzer says, is Pro/ENGINEER Behavioral Modeling. "It's a geometry optimization tool," he says. "I can assign an analysis to measure the location of center mass. We enter my body mass into the system,



Team Raptor's Chuck Pitzer concentrates on the controls as Pinch Point does the heavy lifting.

and it calculates the center mass for the system with machine components. With that information I can keep the exoskeleton from tipping over during its lifting motion." After entering the desired design criteria, Pro/ENGINEER Behavioral Modeling automatically evaluates numerous design options in mere seconds to arrive at the optimum design.

Often Imitated, Never Duplicated

Chuck Pitzer has been using Pro/ENGINEER for eight years, and with good reason: "Nothing compares to it," he says. "I've seen the struggles that other people go through with competitive [CAD/CAE] systems. Everybody tries to mimic Pro/ENGINEER's simulation capabilities, but they just can't get there."

"Pro/ENGINEER really is the next generation design engineering tool – you know, there was 2D, then 3D, then 3D CAD, then solid modeling, and now it's branching off to building real engineering intelligence into models. PTC is doing this better than anyone else now. They're the only ones doing this behavioral modeling, tying it back into geometry behavior modeling. And their structural mechanics are so impressive. It's getting to be seamless, so you can build a super-intelligent model in real time."

"It Frees My Mind"

In the end, Pitzer says, Pro/ENGINEER is a boon to Team Raptor's creativity. "It frees my mind," he says. "Lots of people have ideas and dreams, they want to create and do what they want to do. Pro/ENGINEER gives you the ability to create things, test them out, and know it's going to work. PTC has built a lot of intelligence right into the system."

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