

A new business model for easy to use and application-oriented Motion controllers

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Abstract

In the past years, robots have clearly evolved towards specialized arms: painting robots, welding robots, unloading robots ... However controllers have remained very generic at the expense of simplicity, cost and ease-of-use.

Cerebellum Automation sees in this gap an opportunity for dedicated motion controllers that leverage existing third party motion boards and the familiar PC interface. *Cerebellum's* custom controllers also include application-level functionality usually programmed separately by each customer. This approach, made possible by the fast advance in embedded processor technology, allows for significant cost reductions on medium and high volumes. This business model is similar to the smart camera market that proposes cameras dedicated to parts inspection, object recognition, OCR applications, etc.

Cerebellum Automation's mission is thus to provide its customers with low cost, high performance, and easy-to-use custom motion control solutions.

1. A technological revolution

Software to hardware substitution

The first step in the customization process consists in removing all software modules irrelevant to the targeted application (unused features) from the generic off-the-shelf motion board. This frees significant CPU time that is then used to run application code directly on servo boards, enabling customers to spare the controller altogether. Upon request, *Cerebellum* can even run an IEC-61131 compatible Programmable Logic Controller (PLC) directly on the processor, which again suppresses the need for an extra piece of hardware. Therefore, it reduces hardware costs to their bare minimum: the cost of the servo boards. In essence, this moves hardware costs to software costs, lowering the total cost of ownership for high volume customers.

Cerebellum's thorough knowledge of these hardware and software environments, as well as their long experience in the motion control industry guarantees that this trimming preserves and even improves the systems' capabilities in terms of reliability, robustness and safety.

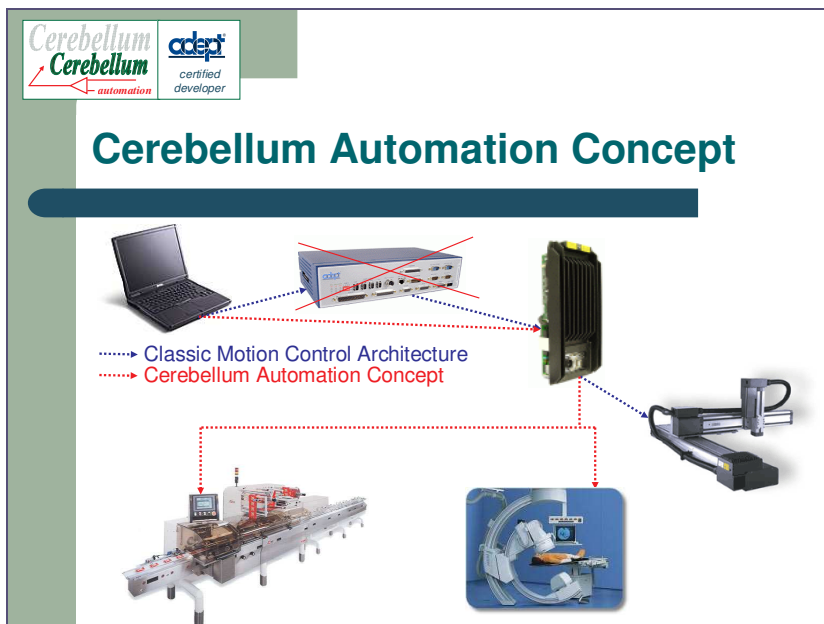


Figure 1: Optimized Motion Controller

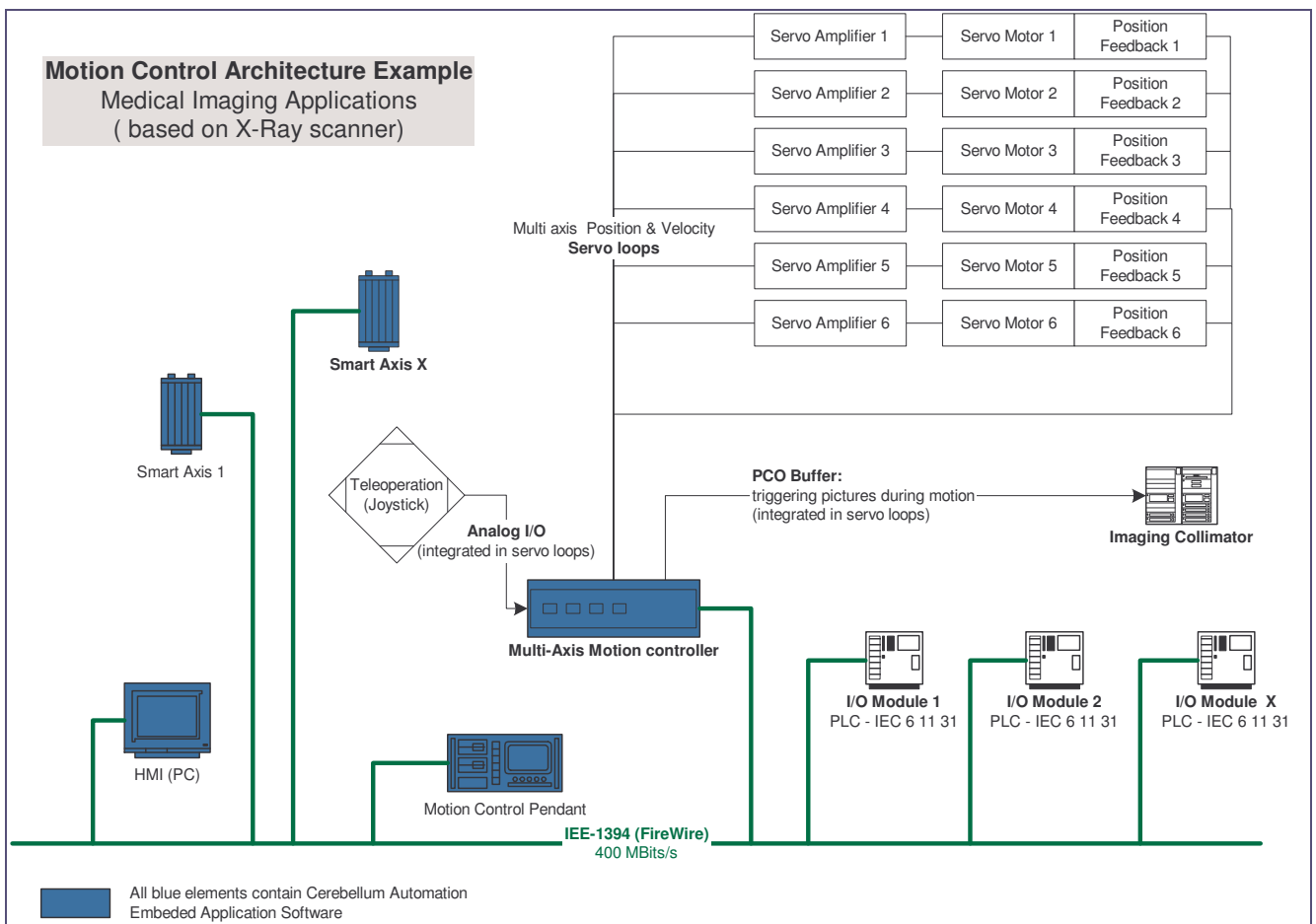


Figure 2: Motion Control Application Example

Customization: controllers dedicated to a single application

The second step is to create task-specific application code and unmatched features, thus bringing plug-and-play controllers to customers who used to do additional application development. Cerebellum offers a ready-to-go motion controller for food packaging with built-in e-gearing, another for medical imaging systems with critical safety features like controlled E-Stop, etc. These custom servo features can reside directly on the motion board thanks to Cerebellum's direct access to the servo code. It also permits the re-use or porting of existing application code written in C or C++ that customers may have developed for previous systems.

The customization goes as far as to include tools like calibration and configuration interfaces, which are presented in the application's business language. All this provides unparalleled ease of use: fewer options and parameters, hence less confusion and complexity, familiar wording and thought process keep the focus on the user's core business instead of divesting attention into technicalities. In short, Cerebellum develops motion control code on demand following any non-standard customer requirement.

Performance gains

Another advantage of Cerebellum's design is the **seamless integration of the different software layers**: the controller, servo and amplifier codes all reside and run on the same processor. One immediate benefit is high-speed reaction on data input, which allows high-level layers to respond instantly to low-level disturbances or variations. Such lightning responsiveness is especially valuable, for example in the medical industry, to synchronize image acquisition and machine locations with the state of an organ like the heart.

This faster communication between layers can also be leveraged to re-generate the trajectory on the fly based on monitored data. Although traditional systems usually handle such events, they do so in tens or even hundreds of milliseconds compared to microseconds with Cerebellum's products. On applications like active compliance for polishing, deburring, grinding, it can speed cycle time by at least 20%, hence increasing output by the same factor.

Finally, our lean architecture enables us to generate the command of the position loop as the output of a higher-level feedback loop (high-level loop closure). For

example, in an optical fiber welding operation, the fiber sends a ray of light to the repeater it is to be aligned with. The alignment is optimal when the light intensity measured in the repeater is maximal. Our controller generates the welding machine's commanded position as a function of the light intensity fed back by the repeater. This higher software integration can even include the simulation layer. Using the same piece of software for the simulation and real worlds renders the transition from one to the other more transparent.

Other major performance enhancements come from our direct access to the servo loop, which lets us tweak and fine tune the algorithm for optimum position tracking and speed. This means that Cerebellum's controller can compensate for any known non linearity such as gravity, dynamic effects, cogging, or any other disturbance specific to the system, like the magnetic field generated by nearby medical devices. This direct access also opens the door to **adaptive control**. This in turn allows parallel data gathering, either as a required part of the manufacturing process or to create versatile machines, able to handle different objects without slowing the cycle time. For applications that have a dedicated step to measure the weight of the manipulated parts, the machine can again integrate that step and replace the scale by analyzing the applied torque. Such information can be immediately uploaded into the plant **management system's** database along with any other controller data for productivity and quality assessment purposes. This could also be used for monitoring and **preventive maintenance** purposes; for example detecting that the average torque is higher than usual may indicate that the gear box is running out of lubricant. Finally, this access to all parts of the firmware on standard, high-volume components brings great value to the rapid prototyping market.

2. A visionary business model

A new breed of motion control designers

In keeping with its strong belief in open architecture, Cerebellum builds its products on existing **third party motion boards**. This guarantees the quality of the boards, designed and manufactured by proven experts, and ensures that support and maintenance are readily available even at the lowest level. However, since Cerebellum doesn't own the motion boards' intellectual property rights, it needs a license on the source code of its embedded software (servo code) in order to customize it. Cerebellum elected to use boards designed for distributed control over **FireWire** high-speed bus, one of the fastest developing field buses in the automation industry. Additional small form factor and high-integration criteria oriented the choice towards boards from Adept Technology, Inc, a leading robot and motion

control manufacturer, and we secured a partnership with them.

The idea of a true partnership rather than a traditional license agreement stemmed from the perception on both sides of the business opportunity. Adept has in the past developed custom servo and/or control features for high potential customers and understands the great value that highly skilled engineers responding to a specific business need can create. However, targeting this market would force the company to completely reorganize, at the expense of Adept's core business (i.e. motion control components), whereas Cerebellum's small and reactive structure is perfectly suited to this typically time- and resource-consuming job.

Anticipating a strong growth of the market, Adept and Cerebellum have modeled a wider network program after their agreement, the Adept Certified Developer (ACD) program. Cerebellum Automation is the first Adept Certified Developer. Introducing an entirely new business paradigm, Cerebellum positions its offer at the junction of component manufacturing and system integration and gives its customers the best of both worlds. It is a one-stop-shop in the necessary transition of manufacturing plants into the information technology age while it leverages for them the latest micro-electronic technologies to their full capabilities.

Market gains

Customers receive the level of customization and understanding of their business needs that, to date, only internal departments can provide, while retaining the cost savings afforded by standard, high volume components manufacturers. This is true not only of the run-time and production part of the motion control application, but also of all less critical software, that each application handles through its own graphical user interface running on a PC. The level of details available to the user is tailored to her particular wishes. Tasks like configuration, diagnostic, and program selection that usually require expert developers to "dig in" are optionally automated and adapted to the application's language and customs. For example, when an output (e.g. valve) that has a significant reaction time needs to be triggered at a precise position independently of the speed of the machine, we would simply ask the user to enter this reaction time instead of requiring her to make a complex calculation herself. Moving the logging, diagnostics and reporting tools, all non time-critical code such as configuration and calibration interfaces, plus any extra interface a customer may desire to a PC is key to achieving true ease of use and of maintenance.

Our customers: systems between robot and machine

The fixed costs involved in custom software development mean that Cerebellum's offer generates most value for higher volume OEM's and integrators, thanks to the economies of scale they can realize and for customers requiring very specific developments.

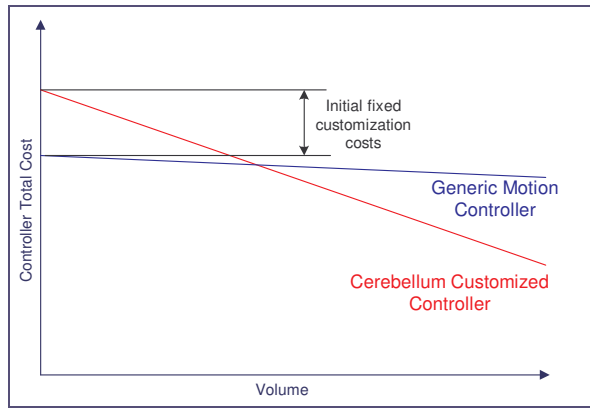


Figure 3: Controller Cost Comparison

Besides these financial gains in hardware equipment reduction, another strong incentive to turn to Cerebellum is that it represents a good (and the only serious) alternative to **in-house development**. Such development often results in proprietary code and components that the company feels forced to stick with for long enough to justify a costly development, even when standard, cheaper components become available. On the other hand, outsourcing to professionals bound by contract and

whose performance directly affects their bottom line makes for higher overall quality. Not only do they specialize in the job, but they are also more thorough in what others may consider details. For example, they hand their customers better documentation, freeing them from a dependency on sometimes volatile employees. Last, outside developers are more dependable and their cost is easier to control than that of employees.

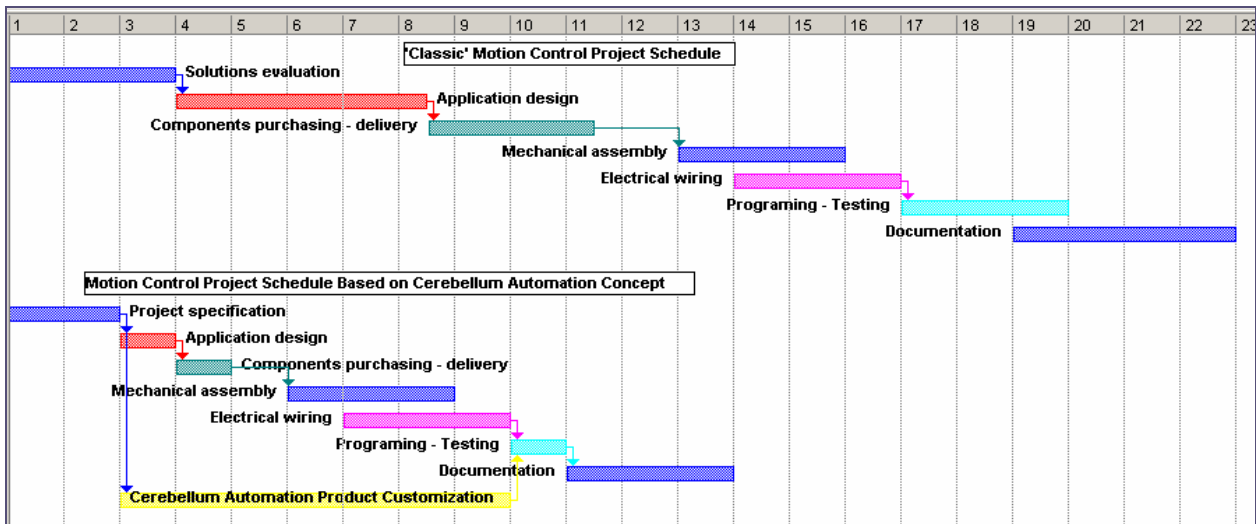


Figure 4: Development Plan Comparison

A win-win-win model

Business wise, Cerebellum's assets are the best mix an industrial company can hope for in a supplier. While it is a small company, with the string of advantages this entails for its customers and for itself, it relies on the strong backing of a major, well-known and reputable component manufacturer. Adept's reference significantly eases Cerebellum's entry on the market since it reassures enthusiastic yet hesitant prospects as to the viability and long term reliability of the company. At the same time, engineers and executives have a very real and direct incentive to deliver in a small size company. Not only does a smaller structure provide an attentive and responsive partner, but its people are totally and unconditionally committed to their customers' satisfaction, since it determines their own personal success. Size is also a success factor from a strictly financial view point: for the kind of business under consideration, that is one with a low cost over margin

ratio, the lower overhead achieved in a smaller organization helps cash flow remain positive.

Conclusion

With its original business model, Cerebellum Automation is leading the way to the next step in motion control: open architecture for distributed smart components. Cerebellum Automation's choice of using standard components bundled with customization services achieves unprecedented performance, cost savings and ease-of-use. Furthermore, it brings customers closer to true integration among diverse devices from different vendors, which we see as a necessary evolution. Eventually motion control users will be able to network such components to build intelligent systems, thus benefiting the whole automation industry. Cerebellum stands as the gateway to this new era.