# HyperSystem Project Proposal

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What can improve the overall quality of human life? The spectrum of human activity is characterized by a quest for happiness, yet sadly, problems from the personal to family to international scale deprive many of this much-needed quality. Much potential to improve the quality of human life lies already in mankind's reach yet is often improperly expended. For instance, the day after man landed on the moon, a decade long milestone for millions of workers, theologian Karl Barth was asked about this technological triumph. He commented: "It solves none of the problems that keep me awake at night." (Is There a Creator Who Cares About You?, 1998) Pure advancement for the sake of boasting guarantees no improvement in human quality of life. By contrast, any idea dedicated to improving the lives of others has the loftiest of foundations. Considering scientific research, manufacturing, and medical procedures, these all play a profound role in improving the lives of others, yet probing these areas may identify ways to yet further advance overall quality of life.

## Goals

**Scientific research** often involves tedious work. One lab performed by students in Dual Credit General Chemistry I with UT Tyler is acid base titration. (Deptartment of Chemistry and Biochemistry, 2016) This involves painstakingly dropping sodium hydroxide into an acid. (Valdez J. F., 2016) Chemistry student Jacob Valdez spent 45 minutes carefully adding over 500 drops of sodium hydroxide to an acidic solution. (Valdez J. F., 2016) Other labs performed in that Chemistry corse such as chromatography, hydrate molecular mass determination, and bomb calorimetry demand more time. (Deptartment of Chemistry and Biochemistry, 2016) Does having a human painstakingly perform these activities present any significant advantage over automated operation? Could not unnecessary time spent "doing" be saved "thinking," that is, analyzing data and advancing scientific understanding – understanding that may one day extend millions of lives from premature death due to heart problems, diabetes, or AIDS?

**Advancements in manufacturing** have always been impeded by high investments in capital and knowledge. Often, both those necessities do not find themselves in the same production environment. For instance, the patent application for rapid prototyping (generally, 3D printing) technology was filed in 1980 by Dr. Kodama. (MSOE University, 2013) However, producing this rapid prototyping machine required significant financial investment – investment that Dr. Kodama lacked. (MSOE University, 2013) As a result, the world had to wait six years until essential capital met at Charles Hull who succeeded building the first 3D printer. (MSOE University, 2013) Comparable stories can be found of creative people devising innovative ideas – but with worse outcomes. Manufacturing has never been more technologically advanced, yet the same barriers hindering the inventors of yesterday are challenging our inventors today. What can be done to open the doors of innovation while lowering financial barriers?

**Medical procedures** usually require that highly coordinated actions be performed. However, the required skills often do not meet what a doctor, nurse, or surgeon actually is capable of achieving. Laser eye surgery (LASIK), for instance, relies on the specific directed positioning of a laser to make incisions in the cornea of the eye. (U.S. Food and Drug Administration, 2000) It is essential that the laser only dissipates corneal tissue. (Marfurt, 2010) The positioning tolerance for these motions is so precise that automated LASIK systems must account for eye movements and respond by correspondingly moving the laser 4,000 times per second. (Marfurt, 2010) This recent development in optical surgery enables patient recovery in under eight weeks. (U.S. Food and Drug Administration, 2000) However, clean-cut, precisely-performed optical instruments have not always been around. The mechanical microkeratome is a bladed tool that makes physical contact with the cornea to shear a section of it off. (U.S. Food and Drug Administration, 2000) In medical practice, this tool is often still used for practical reasons, however, its manual operation introduces scores of surgeon errors to the procedure. (Marfurt, 2010)

A more casual procedure, phlebotomy is the drawing of blood for tests, transfusions, or research. (Bureau of Labor Statistics, 2017) Phlebotomists must draw blood at a target location of the body accurately and repetitively. (World Health Organization, 2014) If done correctly, the patient should feel little or no pain, yet often, the announcement of an approaching blood draw arouses feelings of fear and pain. (Bureau of Labor Statistics, 2017) Why is that? In many cases, poor venipuncture technique on the part of the phlebotomist is to blame for pain experienced during blood tests. (World Health Organization, 2014) The errors reviewed are only a few examples of medical procedure error. Throughout the medical field, there exist operations which are not performed to the degree they could be because of a deficit in technology or human skill. (Reece, et al., 2011) How can the medical procedures be generally improved to minimize unnecessary problems?

Human advancement has made great strides in the fields of scientific research, manufacturing, and medical procedures, yet as considered, there exist areas in which these fields may be improved. Doing so will certainly contribute well to overall quality of human life. Personally, I love helping people. It makes me happy to see others happy. If I can make contribution that enables people to live an average of one year longer, that would certainly contribute to the quality of my life. I also enjoy working with advanced mathematical and engineering designs. Researching and developing designs draws my heart. I can’t imagine being at home without a lab nearby. That is why I am requesting permission to design and build the HyperSystem, a flexible robotic manipulation system. It will be capable of intelligently performing actions that reach a specified goal. For example, this machine will enable researchers to consider information while the HyperSystem performs the experiment; barriers to introducing novel ideas through manufacturing will be lowered by this machine's affordable price; and hospitals can dedicate more thinking resources, such as doctors and surgeons, toward general patient treatment while this machine performs prescribed medical operations. Just imagine, getting blood drawn will be as painless as scratching a portion of skin! Meeting everyday problems with 21st century thinking will mark the HyperSystem's use. The HyperSystem will certainly contribute to overall quality of human life.

## Results

The HyperSystems arises from sets of modular components that perform precise operations on physical matter. The HyperSystem itself is no rigid system; it is a combination of HyperSystem modules that accomplish a particular function. For example, a 3D printer arises from a cartesian coordinate system, an extruder, a build platform, a processor, and other peripheral components. The individual components realize no greater goal, yet the composition of all these parts produce a working 3D printer. Neither can the organelles of a cell reproduce or sustain activity on their own. Likewise, the HyperSystem itself is the culmination of various HyperSystem modules. (Valdez J. , 2017)

Manipulation, being the prime mode of physical interaction, will be employed in HyperSystems via robotic arms, cartesian coordinating systems, and other "positioners" to translate, rotate, and operate a variety of tools. These tools and positioners will be interchangeable on standardized structural interfaces. Thus, a single positioner may perform a variety of tasks such as 3D printing, machining, measuring, or picking and placing, and if the positioner alone is determined unsuitable for operating demands, two or more positioners may be added to the system structure. Information processing or computer interface modules will manage sensory and directive information to intelligently direct activity in accomplishing a goal.

Peripheral features such as cameras, feedstock interfaces, or airtight, thermally resistant housing may also be added to extend machine function. (Valdez J. , 2017)

An excellent example of a HyperSystem may be found in the computer numerically controlled (CNC) machine. CNCs are commonly employed in flexible manufacturing environments where high turnover yet rapid alteration is critical in part production. (Kief & Roschiwal, 2013) Some CNCs house plasma cutters that microbore under one thousandth of an inch. (Kief & Roschiwal, 2013)Other CNCs quickly drill pathways for circuit boards. (Kief & Roschiwal, 2013) Robotic arm CNCs weld car parts together. (Kief & Roschiwal, 2013) The FDM 3D printers seen prolifically today are fundamentally CNCs with filament extruders as a tool head. (Kief & Roschiwal, 2013) From the demanding to casual spectrum, all CNCs are seen to furnish a tool head that is moved by a coordinating system, often in the form of three perpendicular translating axes (XYZ cartesian coordinating system). (Kief & Roschiwal, 2013) If modular translating rails are connected in a way so that precise tool head positioning can be achieved, a HyperSystem CNC may be constructed. (Valdez J. , 2017)

A HyperSystem, however, is capable of much more than a static CNC and its child, the 3D printer. HyperSystem components may be assembled into a traditional robotic system with seven degree of freedom limbs and finely coordinated hands. This will be accomplished by combining the general robotic arm applied to vehicle welding with specifically designed asymmetric hands for gripping. Onboard sensors, power, and processing units will allow the endurance of automation to outperform in everyday jobs like tediously dropping sodium hydroxide into an acidic solution dozens of times. (Valdez J. , 2017)

Successful completion of the HyperSystem demands the production of no particular assembly of HyperSystem modules much as successfully designing interlocking studded plastic toy blocks does not call for the construction of these bricks into a particular toy house. (Valdez

J. , 2017) There merely must be proof demonstrated of the capability to use HyperSystem components in scientific research, manufacturing, and medical procedures. A chemist should be able to quickly and simply build an automated acid-base titration machine without having to worry if a certain part dumps excessive amounts of base into the acid. (Coleman, 2016) The chemist's focus should be on his data not the reliability of equipment. (Brown, LeMay, Bursten, Murphy, & Woodward, 2012) Likewise, to spur on advancements in manufacturing, the HyperSystem must be affordable on both a financial and time budget. (Valdez J. , 2017) This might not be difficult given that many 3D printers begin in the thousand-dollar range and most CNCs are ten to one hundred times that. (Kief & Roschiwal, 2013) Finally, bringing the reliability and affordability the HyperSystem offers to the realm of medical operations, a HyperSystem may be assembled of a robotic arm and gripper that reliably performs extraprofessional functions such as taking blood pressure and temperature. (Valdez J. , 2017) Further advancement in the medical field, such as phlebotomy and LASIK automation, may hinge upon professional approval but also may yield the greatest benefit of all HyperSystem implementations discussed. That will not be probed in the lifetime of this project. However, there are scores of HyperSystem concepts waiting to be developed. In this project, two abstract HyperSystems will be developed and tested from HyperSystem modules to demonstrate successful HyperSystem completion: the HyperLab and HyperBot. Each of these prototypes will be evaluated against specific benchmarks.

**The HyperLab** is a flexible, intelligently-responding CNC. System isolation is approached via a clear, airtight, acoustically damping, thermally insulating enclosure. Four chassis forming rails parallelly situated ease beam deflection under high moment and force loadings due to contact tools while maintaining extreme accuracy. Any significant deviation in rail geometry is automatically accounted for by axis guides. Two modular, perpendicularly situated translating rails precisely translate along the four primary chassis elements to yield three dimensional Cartesian coordination. Additional positioners may also be added such as auxiliary robotic arms to aid in tool exchange and object placement. Perfect four-foot square educational facility appreciation plaque fabrication will serve as a suitable benchmark test for HyperLab successful completion.

**The HyperBot** is a human-like robot with semi-intelligent autonomy. Its biped structure supports walking, climbing stairs, and jumping. Two arms each host seven degrees of freedom attaching to asymmetric human-like hands. While lacking fully autonomous artificial intelligence, simple reasoning units process ocular, auditory, and contact sensory and memory data to achieve a directive. Benchmark success of the HyperBot will hinge upon its cyclic loading and operation of the HyperLab. (Valdez J. , 2017)

In general, HyperSystem capability will be measured against quantitative and qualitative restrictions. (Valdez J. , 2017) It must reliably perform given operations. It must also be flexible permitting modular extension of activity without introducing worry over machine failure. A natural consequence of modular systems, no static control software interface can feasibly exist that deals with every HyperSystem application. Instead, a functional programming language will be interpreted by the HyperSystem modules similar to the way C is used in robot prototyping. The positioners and tools in particular hosted by the HyperSystem must exceed:

- 1 micrometer positioning accuracy; 1 arcminute rotational resolution
- 100 newton maximum dynamic force loading
- Failure less than 1 in 1,000,000 trials

By successfully meeting these stringent requirements, users can be ensured seamless HyperSystem operation.

## Value Added

HyperSystems stand unique, in their class, among flexible, intelligent systems. CNCs are semi-modular, yet in the end, a CNC will always remain a CNC. (Kief & Roschiwal, 2013) Humans are unmatched in their ability to learn and meet unique demands, yet superior HyperBot stamina enables it to repeat manual tasks much longer with surpassing patience. (Pally, 2009) Fully assembled HyperBots may be commercially sold as a novel product. (Valdez J. , 2017) There currently exist no commercially affordable full-sized, human-like robots. CNC machines traditionally run into the tens and hundreds of thousands of dollars. (Kief & Roschiwal, 2013) By contrast, the HyperLab will be affordable possibly commercially available under one thousand dollars. (Valdez J. , 2017)

## Giving Back

In addition to researchers, engineers, and medical professionals, many other parties will benefit from the HyperSystem. Physics class teachers will appreciate its flexibility in designing simple experiments. Offices will be able to spend less resources on interns where a HyperBot performs menial tasks as reloading printer paper, delivering documents, and setting up computer workstations. Janitorial work will definitely be aided by HyperSystems designed to clean. Being such a modular system, not all HyperSystem applications are fully covered in this section. Just as the capability of interlocking studded plastic toy blocks cannot be fully detailed, we will continue to excitedly explore HyperSystem applications.

## Ethical Considerations

The sustainable extension of automated systems into a previously human driven field inherently brings with it ethical considerations. Thousands of researchers, engineers, nurses, and other workers perform jobs that may easily be replaced by automation. Commercial introduction of the HyperSystem will likely bring unemployment to these groups. To minimize this problem, commercial introduction of HyperSystems and packaged versions of it like the HyperBot will only, if ever, follow extensive economic analysis. There is not enough economic understanding behind this project to fully understand all the factors involved in HyperSystem introduction, so for the portion of this project, the HyperSystem will simply be developed, not sold.

## Other Interested Parties

Being a tool for scientists, engineers, and doctors – professionals, it might appear to laypeople that HyperSystems are not intended for them, yet many everyday applications of HyperSystems are waiting to be discovered. Common household chores such as sweeping, sanitizing, and dishwasher loading may be easily automated saving unnecessary time expenditures. Manual landscaping, in particular, is a laborious job where the HyperBot may promise aid to people who care about their landscape.

Expensive marketing can easily be averted in leu of “personal” advertisement. This will involve a group of HyperBots wearing a jacket with the words “HyperBot” followed by a URL where it may be bought online. These HyperBots will then stroll the sidewalks of Dallas, Fort Worth, Austin, and other consumer concentrations. Naturally curious people will then read the URL on the robot’s jacket and go to it online where they see how practical this product is for them. Reposting HyperBot pictures onto social media by some who want to share what they saw in the city that day will spread awareness of this new product. This personal advertisement campaign will launch commercial sales of HyperSystems. However, the primary focus of this project is developing the HyperSystem. Commercial introduction, if ever, will only follow successful development of the HyperSystem.

## Planning

Currently, developing HyperSystems seems unfeasible. There are too many components that must be designed. There is not enough time to adequately test all HyperSystem capabilities. Even the calculations for its prototype motors indicate no material will induct and conduct as required. However, HyperSystem development will continue. New mathematical approaches solving discreet extrapolation will be found. Exotic materials such as allotropes of carbon will be synthesized. Even a suitable workspace will be constructed. In every way, solutions will be found to drive HyperSystem development. In fact, $1,500 have already been allocated to its development due to confidence in the success of this project. Ten reasonable milestones toward achieving that are scheduled below for the 2017-18 school year:

**December 1st Basic module design.** Simple translating and rotating positioner packages will be specifiable as a dimensioned design given part parameters. They will be virtually tested with combinations of point force and moment loadings as well as extramodular electrical and magnetic interference. Also standardized structural interfaces will be adopted or specified. Defining the parts needed for a basic module will confirm successful design.

**December 15th Detailed HyperSystem design.** Information buses will be specified. Total positioner packages will be designed such as the XYZ cartesian coordinating system and the five-axis robotic arm. ExtraHyperSystem tools such as filament extruders, grippers, and drills will be extendable on the HyperSystem. Current, the author foresees these general qualifiers specifically being applied toward:

- Installing a 35000rpm Dremel with 1/8th in. spindle with boolean operation
- Server driven machine control with a simple grey-code micro-processing just-in-time interpreter
- Submicron precision contact probe

- High power direct current motor for a custom spindle with adjustable chuck possibly for automatic tool changing

I will talk this design over with Mr. S. Warren to ensure major errors are accounted for. Again, a complete part list definition will seal a stamp of success for detailed HyperSystem design.

**January 30th HyperLab prototype.** A multi-tool XYZ coordinating system will be able to impose computer commands on machine elements directed toward laser, grinding wheel, and other modes of object manipulation. One must be able to command the HyperLab to cut a 20cm × 20cm square from any scrape nonferrous material like aluminum, PVC, or hardwood with a language specific adoption of the following G-code:

```
000 M1
001 G1 X0 Y0
002 G1 X1
003 G1 Y1
004 G1 X0
005 G1 Y0
006 M0
```

The finished part will be visually inspected and measured against a centimeter ruler to confirm dimensional conformity within 10µm of a 20cm × 20cm plane. Material thickness should at least be 5cm. While I would also like being able to cut ferrous materials, they will not be needed anywhere in this project.

**February 5st HyperLab improvements** will exceed the coordinating requirements bulleted at the end of the “Results” section. Also, peripheral features such as isolating housing, on board cameras, and environmental regulators may be added. Specifically:

- Clear housing will minimize chemical, acoustic, and thermal interaction of the internal and external machine environments
- Air pump can lower internal atmospheric pressure to 5psi reducing sound and heat transmission
- Simple clamping mechanisms allow a workpiece filling the entire volume of machine work volume to be clamped and unclamped in under one minute

Simple programmatic functions will be tested and documented. Simple errors introduced by positioners will be minimized. Benchmark completion of this deadline means the complete documentation of a set of commands interpretable by the HyperLab and corresponding machine effect.

**February 15th HyperBot design** will detail structural and motive parameters given maximum applied loadings and moments at the end of all limbs and all continuous impacts along the surface. This will be modeled where every point ($\boldsymbol{r}$) within the volume of the HyperBot's structure ($V$) is a tensor array ($A$) of maximum actual ($\boldsymbol{\sigma}_{max}$) and ideal yield ($\boldsymbol{\sigma}_{yield}$) normal and sheer stress in three directions and temperature ($T$). In mathematical terms:

$$A = \left\{ \left( \boldsymbol{r}, \boldsymbol{\sigma}_{max}, \boldsymbol{\sigma}_{yield}, T \right) \middle| \, \boldsymbol{r} \in V, \ \forall \boldsymbol{\sigma}_{max} \ll f_{f.o.s.}(T) \cdot \boldsymbol{\sigma}_{yield} \right\}$$

Discrete power storage units will be explored with potential candidates selected for design. Additional mobile unit necessities will be examined such as acoustic, thermal, and intravibrational impacts.

**February 25th Modules refined** after HyperBot design will implement advanced mathematical reasoning as opposed to "trial 2 performed best" to find a discrete solution for continuous (or very large) modular parameters as seen in figure 1. This will specifically be used in improving positioner efficiency while increasing electrical and thermal conduction. A nondiscrete micro-positioner may be designed for intraHyperSystem repair and manipulation meeting the benchmark of having a functional part list for any given parameters. By this point, I will have completed most of my differential equations class so I can take advantage of methods for solving differential equations to find the most efficient possible combination of parameters.

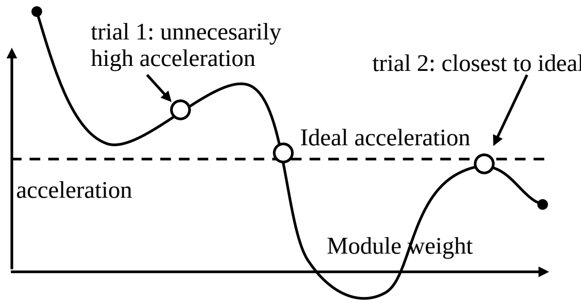


Figure 1. Mathematical modeling will find the best solution, not just a close one

**March 5st HyperBot virtual and local tests** successfully account for all combinations of force and moment loadings with statistical frequency on HyperBot limb loading points. In mathematical terms, a cartesian product of maximum force loadings at every limb appendage (left and right hands and feet; $\boldsymbol{F}_{app.}$) combined with statistical likelihood ($P$) will find evenly distributed subyield internal stress in the structural body of the HyperBot.

$$\forall \prod \boldsymbol{F}_{app.} \ll f_{f.o.s.}(P) \cdot \boldsymbol{\sigma}_{yield}$$

Continuous impact along HyperBot surface with statistical frequency will evenly distribute stress along the HyperBot in the subyield range. Also, reasonable vibration gradients will be computed throughout the HyperBot to ensure structural integrity. Virtual qualitative tests will meet acceptable acoustic, odor, and temperature impacts. Manual geometry will be applied toward small and large object handling.

**March 15th HyperBot production schedule** will produce a HyperBot within two workweeks. This schedule will employ me less than five hours per day for ten days to build a HyperBot from imported parts. Successful completion of this milestone means successfully building a HyperBot within two workweeks.

**March 25th HyperBot prototype will be tested** in a variety of situations ranging from the harsh outdoor environment to fast-paced factory line. Since the HyperBot must perform competently in an unknown variety of situations, there really can exist no complete test of the HyperBot's ability. For this milestone, the HyperBot will perform with indistinguishable quality from that of a human in the following tasks:

- Clamping regular workpieces in the HyperLab
- Assembling burger ingredients according to a demand list
- Unstacking and restacking 10 chairs

The finished products from these three exercises along with the time required to perform each activity will be given to a blind judge, likely Isaac, who did not see the activity performed. The judge will then be asked whether they think a robot or human performed that trial of the activity. If the judge is correct for more than 90% of all trials in distinguishing who performed the activity, the HyperBot will have failed. A success will be close to 50% correct.

**April 5th Final HyperBot** will be productive for research, manufacturing, and medical procedures. It will meet the benchmark of helping a HyperLab manufacture a plaque of appreciation for Global High given the unmachined workpiece and preprogrammed instructions for the design.

**Ancillary Work.** Likely between April 5th and the showcase, I will discuss with Mr. Warren the capabilities and shortcomings of the HyperSystem and conduct required capstone documentation. During this entire project, I will have professionally been documenting the

HyperSystem design in my HyperSystem Notebook. This notebook already contains meaningful design content and will be expanded over time.

The capstone presentation will involve a setup with three stations. As intrigued ones walk around, they will first see burgers being prepared from boxes containing frozen ingredients to the hotplate and prep table to the assembly line to a pyramid of completed burgers. Since giving out food calls for documentation and licenses, the burgers will not be given out. Another team of HyperBots will bag and dispose of the burgers. Next, a HyperLab will be machining a piece of the HyperBot's structure. While machining, other HyperBots will be assembling a new HyperBot. Finally, three to five HyperBots will be standing where showcase attendees can ask them questions. This setup is illustrated in figure 3.

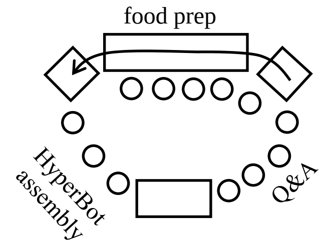


Figure 3. HyperSystem showcase setup features three stations.

## Resources and Feasibility

Given the scope of this project, much time and money will be required for the HyperSystem's development. Financial blunders will be averted by extensive planning at the cost of time spent. Figure 2 shows how this trade off may occur. An equilibrium of $1,500 will be spent over the corse of the school year with 12 hours per week. Much time has already been spent learning advanced mathematics, such as Calculus, which will continue to be built upon in analytical engineering. The majority of time beyond learning will be spend designing HyperSystems and analyzing possible failures that may occur. The

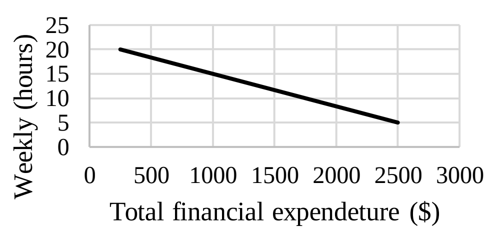


Figure 2. Trade-off between time and money spent at maximum output.

HyperSystem modules composing a HyperLab may cost around $250. Poor manufacturing technique may double the amount of money required. A HyperBot will include onboard power and processing units. These likely will cost around $250. The HyperBot itself will likely cost $100 to produce. Since only two weeks are allotted toward HyperBot manufacture, there is no time for error neither will money be allocated toward HyperBot production mistakes. A corner of a personal garage will be transformed into a workspace with $150 allocated to manufacturing equipment and tool furnishment. Unaccounted expenses are estimated to run about $100, however, a total of $500 extra will be preserved for this project. A total of $1,500 will be spent of HyperSystem development.

This project must be completed on time. All ten milestones are expected to be reached on time. Additional help is provided by means of a former manufacturing professional, Scott Warren. Three weeks ago, Mr. Warren already agreed to mentor this project. His manufacturing experience may further extend HyperLab development.

## Conclusion

I request permission to design and produce the HyperSystem, a flexible robotic manipulation system. An automated manipulation system is a programmable tool that can perform precise operations on a subject. The 3D printer furnishes a fine example of an automated manipulation system. A robotic manipulation system can intelligently perform precise operations on a subject. Additionally, this system is unique from existing manipulation systems in that it is flexible. Insolated, the components of a 3D printer achieve no greater goal, yet combined, they 3D print. Likewise, a HyperSystem is the calumniation of various HyperSystem modules. Robotic arms, cartesian coordinating axes, and other “positioners” are interchangeable along standardized structural interfaces. The tools hosted by the positioners are themselves interchangeable allowing a single positioner to perform a variety of functions such as picking and placing, 3D printing, or machining. Peripheral features such as an airtight, soundproof, thermally resistant housing may be added to support machine functions. The culminating system will be capable of improving overall quality of human life.

Post script: With sincere 17-year-old intentions, I set out to build an industry shaking system however I accomplished none of my tangible objectives. Nonetheless, I learned much useful information during the scope of this project – which I will take with me to future work.

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