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A HyperSystem of Things

Present manufacturing conventions limit production system flexibility by using specialized machines that cannot serve any other role than their original. This introduces unnecessarily high machine rigidity requiring companies to obtain new machines for different manufacturing processes. The HyperSystem is a set of modular components that overcomes those hurdles by enabling modular assembly of production machines. This allows a production machines to easily switch from performing one manufacturing process to a different one. Other processes performed in the manufacturing environment, though, do not currently have machines dedicated towards performing. The HyperBot, a human-like robotic assembly of HyperSystem modules enables automation of even these deemed unimportant to automate processes.

Keywords: HyperSystem, HyperLab, HyperBot

I am writing about HyperSystems because I want to show you why the sheer variety of manufacturing operation specific machines render present manufacturing conventions unproductive in order to explain how a HyperSystem can improve manufacturing system productivity.

Background

Following the second world war, Germany was economically crippled (Kief and Roschiwal 3). Divested cities held broken manufacturing machines that fueled the war effort

(Kief and Roschiwal 3). A shortage of skilled workers employed the few manufacturing machines that remained in usable condition, yet the demand for goods was unlimited (Hubbard and O'Brien). To fully utilize existing manufacturing machines, German firms employed workers from Western Europe (Kief and Roschiwal 3). At the same time, the German Tool industry began developing more manufacturing machines and exporting them (Kief and Roschiwal 3). Compared to the United States' 15-year-old manufacturing machines, these new German machines offered superior production quality with faster production time and lower machine cost (Kief and Roschiwal 3). Importing these machines from Germany, the United States realized mass production (Kief and Roschiwal 4). However, the introduction of the buyer's market in the 1970's saw a new worldwide trend emerging (Hubbard and O'Brien 4).

With increasing globalization, shorter product life become the norm for most products (Kief and Roschiwal 4). Manufacturers had to shift away from rigid mass production to more flexible production (Hubbard and O'Brien). Large companies across the globe were looking for a machine that could manufacture parts according to a computer specification precisely, quickly, and efficiently (MSOE University). The introduction of the computer numerically controlled (CNC) machine accommodated this need (Kief and Roschiwal 10). A CNC is a machine capable of performing a variety of manufacturing processes such as sawing, measuring, and multipoint precision boring (MachMotion). Combined with other CNC's and a workpiece manipulation system, the flexible manufacturing system emerged (Gelders, et al.). The flexible manufacturing system is an automated system that can programmatically produce any product desired (Gelders, et al.). These systems place the need for humans in production. (Gelders, et al.). First tested in

Japan, visitors "from around the world … were astounded by the unmanned production in unlit factory shops" (Kief and Roschiwal 6).

However, flexible manufacturing systems are not limitlessly flexible (Gelders, et al.). Manufacturing operations like cutting, drilling, and milling are readily interchangeable on a single machine, but specialized machines still routinely perform manufacturing processes like debarking, lapping, and electron discharge machining (Todd, et al. 2, 86, 173). Increasing the flexibility of these machines would allow an increasing overall flexibility of manufacturing systems.

MANUFACTURING SYSTEM FLEXIBILITY

Increased manufacturing operation flexibility generally follows an increased frequency of manufacturing process use (Kief and Roschiwal 217). The more any operator uses a system, typically that system performs a broader variety of tasks (Kief and Roschiwal 237). This, in turn, demands higher system flexibility (Gelders, et al.). Since frequency can increase indefinitely, one would expect flexibility to likewise increase uncapped, yet according to statistical laws,

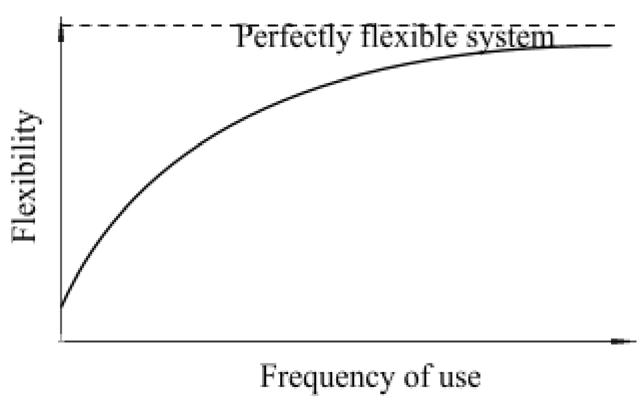

Figure 1. Manufacturing process frequency of operation approaches a flexibility limit.

increasing standard deviations from a statistical mean follows a nonlinear decrease in population membership likelihood (Stewart), system flexibility gradually approaches a limit of necessity. Such a system that cannot be more flexible is a perfectly flexible system as depicted in figure 1.

Even with the identification of flexibility, perfectly flexible system advent remains to come. Many machines have come close to ideal flexibility (Gelders, et al.). For instance, the universal CNC can quickly and easily transform from a drilling machine to a routing machine (Gelders, et al.). In both cases, a toolhead must precisely move with high force loadings, sometimes exceeding 10,000 pounds (Todd, et al. 7-9). However, to convert either a drilling or routine universal CNC to a 3D printer, which does not demand force loadings anywhere even close to one pound, is trivial (Kief and Roschiwal 203-209). The structure of the universal CNC is unnecessarily capable of meeting 3D printer force standards (Kief and Roschiwal 47, 203-209). Is it possible, though, to design a system able to meet demanding manufacturing process requirements, such as high force loadings, but at the same time flexible enough to convert into another machine able to meet an entirely different set of standards?

The HyperSystem

The HyperSystem is a modular system composed of HyperModules designed to increase manufacturing system flexibility (J. Valdez, HyperSystem Notebook 11). Just as the construction of interlocking plastic toy block structures calls for no particular plastic block provided the structure meets and end goal, likewise, HyperSystems are modular systems demanding no particular HyperModule so long as the HyperSystem achieves an end goal (J. Valdez, HyperSystem Notebook 11). Per HyperSystem Project Proposal:

> 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 … 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. (J. F. Valdez, HyperSystem Project Proposal 5)

Different HyperModules serve different purposes (J. F. Valdez, HyperSystem Project Proposal 5). A 3D printer is not entirely motors (J. F. Valdez, HyperSystem Project Proposal 5). Neither is DNA the only constituent of a living cell (J. F. Valdez, HyperSystem Project Proposal 5). Really, the practical culmination of any system realizes itself only when a variety of components cooperate together successfully, and so, a variety of HyperModules compose HyperSystems (J. F. Valdez, HyperSystem Project Proposal 5). Some of the HyperModules translate or rotate an attached object (J. F. Valdez, HyperSystem Project Proposal 5). Others host optical, acoustic, chemical, and pressure sensors (J. F. Valdez, HyperSystem Project Proposal 7). Even more HyperModules handle information, electrical power, and hydraulic or pneumatic fluid (J. F. Valdez, HyperSystem Project Proposal 7). Combinations of translating and rotating HyperModules may build a multi-axis arm which itself is a modular component (J. F. Valdez, HyperSystem Project Proposal 5).

HyperModules can compose a crane system (J. F. Valdez, HyperSystem Project Proposal 10). They can make a quality control system (J. F. Valdez, HyperSystem Project Proposal 10).

Unimaginable combinations of HyperModules could make virtually any system desired (J. F. Valdez, HyperSystem Project Proposal 10, 11). However, two particular HyperSystems meet the needs of a very large amount of systems.

HyperLab

The HyperLab is a CNC-like, robotic manipulation system targeted at automating workpiece operations. It replaces the expensive and rigid CNC by offering flexible yet efficient machine operation at low cost. (Kief and Roschiwal 131)

Currently, the manufacturing industry uses highly sophisticated machines called CNC's to precisely cut, drill, and mill workpieces (Kief and Roschiwal 131-133). These rigid machines position a toolhead, typically a drill, saw, or milling head, in programmed paths over an object (Kief and Roschiwal 131-140). The result is a precisely defined resulting part (Kief and Roschiwal 140). From the home to the factory, parts made on CNC's manifest themselves as door handles, car engines, and keys (Kief and Roschiwal 141). The HyperLab is like a CNC possessing rails, a cartesian coordinating system, and a spindle head, yet it is more flexible than a CNC (J. Valdez, HyperSystem Notebook 11). If a company had fifty universal CNC's steel milling – a process requiring high force loadings – it would be a waste of precious machine time to employ some of those machines on 3D printing – a delicate, low force process (Gelders, Van Looveren and Van Wassenhove). Instead, that company would likely buy 3D printers (Hubbard and O'Brien). However, if that same company owned fifty HyperLabs currently purposed as milling machines, replacing the inexpensive machine chassis would manifest itself as the affordable solution to convert milling machines to 3D printers (J. Valdez, HyperSystem

Notebook 10). What is more, while CNC's typically run in the tens of thousands, a HyperLab will be affordable at $100 (J. F. Valdez, HyperSystem Project Proposal 5-9).

Production lines, instead of hosting thousands of specialized, hardwired factory machines, could simply trace an uninterrupted line of HyperLabs (J. Valdez, HyperSystem Notebook 11). Possibly, the first set of machines would measure the workpieces entering the line, the next set of machines performing subtractive operations, and the final set of machines would finish and check product quality (J. Valdez, HyperSystem Notebook 11). These flexible factory lines could quickly switch from engine block manufacture to laptop case production (J. Valdez, HyperSystem Notebook 11). A factory lined with HyperLabs would truly be a perfectly flexible manufacturing system (J. Valdez, HyperSystem Notebook 11).

HyperBot

Workplace operations routinely call for sub-100-pound object handling. A biped humanoid robot can increase productivity by replacing human time allocated to such tasks (J. F. Valdez, HyperSystem Project Proposal 8). The HyperBot is that robot (J. F. Valdez, HyperSystem Project Proposal 8). It intelligently evaluates sensory data against directives to achieve a goal (J. F. Valdez, HyperSystem Project Proposal 8). Possessing two triple jointed arms terminating at five-fingered asymmetric hands, the HyperBot can match and surpass human dexterity in many tasks such as loading manufacturing machines and lines with raw materials, visually inspecting complex parts, and coordinating with other HyperBots to lift heavy workpieces (J. F. Valdez, HyperSystem Project Proposal 8). In fact, one of the most time-consuming operations a CNC contends with is replacing toolheads during machining (Kief and Roschiwal 61-71). A one inch diameter router bit might be necessary to "rough out" the workpiece, but then a quarter inch bit becomes important to add fine detail (Kief and Roschiwal 62). There, the HyperBot saves precious human time (J. F. Valdez, HyperSystem Project Proposal 8). While exceeding manual capability, the HyperBot is affordable, so it may replace humans in hazardous environments like dropping coke inside a blast furnace chamber, operating on high voltage electrical supplies, or flagging down bulky objects from crane suspension (J. F. Valdez, HyperSystem Project Proposal 8).

Future work

The HyperSystem will greatly benefit manufacturing systems, yet its benefits may extend farther. How many hours do residents spend on household chores loading the dishwasher, folding laundry, and the like? The HyperBot saves that time. Nonindustrial yet systematic operations such as library book indexing, inventory checking, and food preparation will greatly benefit from HyperSystems like the HyperBot. Given the enormous changes yet to come, a complete HyperSystem of Things will not see itself anytime soon in the future.

Conclusion

The present manufacturing system of things is limited in its flexibility. That calls for a production machine matching the capability of specialized machines while at the same time affording flexibility. The HyperSystem is a near perfectly flexible system of modular components that can assemble to make machines meeting those requirements. (J. Valdez, HyperSystem Notebook 3) To specific constructions of modular components are the HyperLab and HyperBot will surpass present manufacturing conventions and costs in production. (Gelders et al.) The HyperSystem is one giant leap towards improving manufacturing system productivity.

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