

Discussion about Design with Prof Kimura, June 13, 1991

Background

I visited Prof Fumihiko Kimura on June 13 to plan my visits to companies and to discuss research problems in design. Prof Kimura is an expert on the mathematical models of complex 3D surfaces. He did his PhD with Prof Hosaka, who, along with Coons in the US and Bezier in France, are responsible for all math models of surfaces used in CAD (Computer-Aided Design) of automobiles and airplanes world-wide. Prof Kimura led two national big projects through MITI on development of surface modeling software for CAD. Toyota, among others, is a major user of this software.

Kimura is a respected thinker about design research, product modeling, CAD and CIM (Computer Integrated Manufacturing). His view is entirely that of the design engineer focussing on performance of the product. He is less aware of design for producibility issues and does not know Prof Fujimoto. We had a wide-ranging discussion of many issues: what the elements of next-generation CAD should be, how to effect technology transfer from R&D to practicing engineers, and what characterizes design problems in general.

Kimura's Current Research

He has just launched an industry-funded project on product modeling to support next generation CAD. He admits that he has no experience as a designer himself and it is interesting to hear him bemoan the complexity of design as it is described by engineers. As an academic he is looking for clean categories and well defined steps in the design process. What he finds instead is intuitive leaps, a mixture of primary and secondary issues being considered at once, and unlikely linkages between causes and effects that "good designers" seem to know but are not visible to the uninitiated.

The problem of technology transfer is especially perplexing. He wants to define next generation CAD but can't describe it to engineers who know only existing CAD. They in turn cannot imagine what does not exist and cannot formulate or describe design tools they do not have and for which they substitute experience, intuition, and naive or sophisticated mental models.

He notes that the IMS (Intelligent Manufacturing Systems) proposal is blocked by doubts about the efficacy of technology transfer. Apparently he feels that this is an illusion created by typical communication barriers between researchers and engineers, as described above. Foreigners are especially prone to think that Japanese engineers are holding back whereas the Japanese feel they are making rather full disclosure. Problems like this lead to bad feelings and slow progress.

A Design Technology Transfer Example

To encourage this discussion, I brought up the case of IHI's shipbuilding methods. These were developed over about 15 years beginning in 1955 by Mr. Shinto, who became famous for them. They are a sophisticated extension of US modular shipbuilding methods developed by H J Kaiser during the war. The extensions include

- * adding statistical process control so that very large modules can be built accurately
- * choosing module shapes skillfully so that most of a ship is made of simple modules, and
- * training groups of workers to deal with the same type of module day after day.

The method is an application of Group Technology, a technique that combines similar but not identical things into groups where they are treated as though they were identical. Except for this application to shipbuilding, Group Technology usually is applied to machining.

The entire approach used at IHI apparently grew almost organically in the minds of its originators. In the early 1970's the US Navy hired a consultant, Mr Louis Chirillo, to visit IHI, write down their method, and transfer it to US shipyards to reduce the cost and construction time of Navy ships. This effort took him over 5 years and resulted in about 2 feet of shelf space of reports. These reports describe the method in full pedagogical form, complete with terminology, hierarchies of entities (Grand Block Modules, Modules, Submodules, Panels, Subpanels, etc), kinds of production entities (simple flat panel in large quantity, panel curved in one direction in small quantity, etc.), and procedures for negotiating contracts, painting compartments, bending pipes, and so on.

Chirillo told me that he had to evoke all of this from the IHI people. In fact, they did not have or use any of this terminology. He just held a tape recorder up while they talked, then got a running translation, then interpreted it and wrote it up. After several iterations with IHI comments, the final reports emerged.

Ultimately, technology transfer to US shipyards resulted from a combination of these reports plus on-site tutoring at the yards by IHI personnel for up to a year. If the reports had not been written, it is doubtful that technology transfer could have succeeded.

This story is interesting because it indicates the efforts which may be necessary in order to determine what designers and design managers do. They are not used to formalizing their activities and rarely have time to do so. An outsider can hardly find out by making superficial visits or talking in generalities. An alternative is to be or have been a designer oneself, but this is rare in academia.

Kinds of Design

It is customary to distinguish three kinds of design: original, variant, and routine. These roughly distinguish design of totally new things, redesign of existing things, and routine modifications of catalog items. Prof Kimura also distinguishes products whose design method is understood and those whose method is not. He feels that basic automobiles and copiers, for example, are understood, whereas space stations are not. There is little to be learned from studying cars and copiers, he feels. One can observe a set process in operation but cannot witness the struggles that occur when something really new is being created.

If we acknowledge that designing a car or copier can be quite challenging, what is it that makes it so? Again roughly speaking, he is distinguishing innovation from complexity. Cars are merely complex, made so because they comprise a combination of very many but probably simple things. These things are well modeled in an engineering sense, he feels, so the real challenge is past. This is probably the reason why he does not feel that Prof Fujimoto's work bears directly on the main challenges of design research. "It's just a social problem," says Kimura.

Yet if cars were a done deal, so to speak, then why are so many mistakes made designing them, why do they take a long time, what is it that some companies do that permits them to design cars faster and better, and is this question worth pursuing?

And, is Prof Kimura seeking an unachievable goal in trying to capture innovation? Can one imitate the experience of a designer who "knows" that a particular structural material, when used in a certain way, plays, say, a vital electromagnetic role in the function of the product, desirable or undesirable, and that this effect or a chain of such effects must be considered when designing with that material? Can such knowledge ever be captured? Put another way, could Mr Chirillo have written his reports in 1955, 1960, or 1965, while Mr Shinto's work was still evolving?

Another way to pose the question is to ask if computers can ever be more than mere tools that help designers in routine ways. To go beyond the routine requires "knowing" a great deal about nature or capturing it in engineering and mathematical models. Engineers must be able to construct such models

with the expectation that behavior they did not anticipate will be represented, and represented accurately. This might be called Data in, Genius out. (See the report on Prof Tomiyama, who is attempting something like this.)

Finally, can such tools be generic, or will we have copier design systems, car design systems, and so on? Prof Kimura worries that the latter will be the only result.