Further Reading

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Original Publication

"Intentionalities" 60-63 and "Computer-Aided Participatory Design," 102-123, *Soft Architecture Machines*. Cambridge: MIT Press, 1975.

From *Soft Architecture Machines*

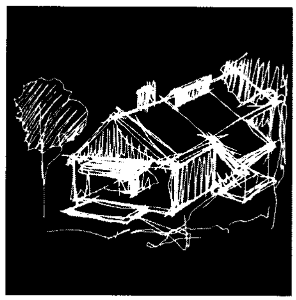
Nicholas Negroponte

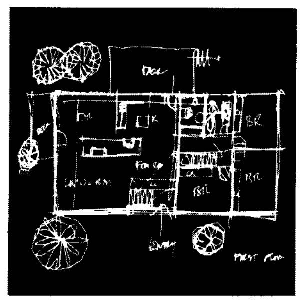
Intentionalities

I propose that a common oversight in the computer recognition and generation of visual material is the disregard for the intentions of the image. What I *mean* to say is more important than what I actually say. The intimacy of a dialogue can be in some sense measured by the ability of each person to recognize the intentions of the other. For example, in cases where people are not well acquainted and from different cultures, speaking to each other can become a profession (diplomacy) where it is very necessary to say exactly what is meant and to be well trained at understanding what is meant.

With two good friends, codesigners, husband and wife, this is not true. A well-developed working relationship is in fact characterized by one party's leaving a great deal of information for the other party to infer and assuming it will be inferred correctly. As Oliver Selfridge puts it, an intimate, interactive conversation is, in some sense, the lack of it.

Unfortunately, intentions can only be recognized in context, that evasive and omnipresent condition. But, in many cases, even the crudest definition of context (like "now we are going to talk about structures in architecture") can help what Kaneff (1970) has titled The Picture Language Machine. If you are sketching a plan and I know you are sketching a plan, even though some lines might replicate the schematic cat, I will do my best to assign to the lines a projective geometry or diagrammatic meaning associated with the built environment. However, if I know you are a lover of cats, there might be room (at some point) for equivocation, to the extent that I might have to ask, "Do you mean . . .?" There is nothing wrong with asking, but note that the need for asking is not necessarily a result of the level of detail, abstraction, or diagrammatic scribbling. The fact that most realistic rendering demands the same inference making and causes the same ambiguities is shown by trompe l'oeil painting and Ames experiments in the psychology of perception.





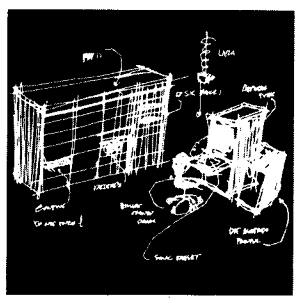


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Figure 23.1. Examples of drawings made on the Architecture Machine as part of the so-called Cavanaugh experiment, designed to determine personalized drawing habits. Each figure is a computer display of every tenth point recorded by the data tablet.

Figure 23.2. The Sylvania data tablet.

To make inferences about a statement requires a knowledge of the world. To make an inference about the intention of a statement requires some knowledge of the person making it. For me to begin to make inferences about your intentionalities, except at the very crudest level (of contradictions, slips of the tongue, mispronunciations, etc.), requires that I know you (even as slightly as knowing that you are American). That is, I need a model of you. Following some work with Gordon Pask, we proposed in "HUNCH—An Experiment in Sketch Recognition" (Negroponte, Groisser, and Taggart, 1972) that man-computer interactions should be supported by three levels of model. From the computer's point of view, these include: (1) its model of you, (2) its model of your model of it, and (3) its model of your model of its model of you.

The first level is a straightforward model of the user, ranging from his habits and mannerisms in sketching, for example, to his attitudes toward architecture. This model is continually exercised as a prediction device and supplier of missing information. Its validity is easily measured and tested in terms of the closeness of fit between the anticipated and the actual intention as manifest at some increment of time later (a millisecond, an hour, a year). Notice that in no sense can such a model be fail-safe; in fact, the very idea of fail-safeness itself is the wrong attitude toward the problem. In terms of implementation this model would be passive (and hence exhibit no inept behavior) at the beginning. After some period of time (with people this varies from personality to personality), this model is deployed to venture guesses and would inevitably make errors. Consider the process we go through in getting to "know" somebody. You will remember stages of attempting to make no predictions, times of wrong second-guessing, and later periods of "knowing" him or her. This is dramatically amplified if the other person is from another culture, ill-versed in your language.

The next level of model is the *computer's model of your model of it.* This is critical to inference making because one tends to leave implicit only those issues that one *assumes* the other party will understand (implicitly). This model grows out of a felicity of matches between the inferred information and the intended information. If, for example, the computer correctly assumes that you meant "door within the wall," it can draw the added inference that you *assumed* it would. Note that this model can only grow out of correct matches.

The last level of model may appear overly circuitous and somewhat fickle; however, it has unexplored (to my knowledge) implications for learning. It is the *computer's model of the user's model of its model of him.* In human relations, what I think you think that I think of you is as important as (and can be more important than) what I really think of you. I suspect that forthcoming research will reveal that this model is crucial to learning about people on a person-to-person level. This is because a deep acquaintance can be described as a state of convergence between this third level of model and the first. When your model of my model of your model of me is almost a replica of your model of me, we can say that you know me; in terms of a human relationship, that we have reached a level of confidence and trust.

Computer-Aided Participatory Design

User Participation in Design

The idea of and need for user participation in design have surfaced in the past five years as a major (and fashionable) element in both design education and professional practice. A recent synopsis can be found in Nigel Cross's (1972) *Design Participation.* This interest in participation follows from a general feeling that architecture, particularly housing, has been inadequate and unresponsive to the needs and desires of its users. One cause for this seems to be that the design of housing is in the wrong hands, that is, in the hands of an outside "professional," rather than of the resident. The question is: Can the resident participate in or control the design of his own house?

The concept of user participation can be traced back centuries in indigenous architecture. In contemporary architecture and planning it is generally credited to Paul Davidoff's "Advocacy and Pluralism in Planning" (1965). Some architects view participation as a form of giving up, capitulating to the individual who knows less than the expert but is willing to live in his own mess. Others see it as the most promising and sensible, if not the only, approach to ensuring responsive physical environments. The subject is, to say the least, controversial. Ironically it is generally studied and pursued by designers who view computer-aided design

From aap noot mies huis *by N. J. Habraken Amsterdam: Scheltema & Holkema, 1970. Translated from Dutch and abbreviated, from* The Responsive House, *edited by Edward Allen (Cambridge: MIT Press, 1974).*

Nowadays man lives in an unnatural relationship with his domicile. This artificiality becomes apparent when we know which types of natural relationships exist. There are six natural types of relationships. The seventh form of relationship brings into being non-homes.

The first . . . is the simplest; the occupant builds his own house with his own hands.

The second type of individual relationship is that in which the craftsman . . . offers his services. This relationship was very often responsible for housing in western history.

The third type of individual relationship is that in which the architect acts as intermediary between occupant and craftsman. . . . There are very few who can afford this type of relationship. . . .

The first collective type of relationship is that in which the community builds collectively the houses it needs, and does this without delegating the labor to craftsmen.

The second collective type differs only by the delegation of some or all tasks to craftsmen.

The third collective relationship is that in which the community and craftsmen do the actual building. The architect acts as the specialized intermediary.

The seventh relationship is a nonrelationship. None of the previous types of relationship are found in mass production building. This seventh type is characterized by the fact that the occupants really take no part in it. They are unknown during the process of decision which leads to the production of dwellings.

It is for this reason that . . . nothing reaches the architect from the group of the "anonymous multitude" of people. The architect is commissioned by another specialist who is no more the occupant than he is.

as an antipodal effort, as a tool for the military-industrial complex only.

The underlying assumption of user participation is that individuals and small groups (a family, a neighborhood) know what they want or, at least, can learn what they want. The concept further assumes that they can apply this understanding in concert with a "competence" to realize designs for the built environment. The results are an apparent (though not necessarily real) democracy in decision making, the consequence of which is ideally a responsiveness in architecture. This approach shortcircuits many of the traditional roles of the professional planner and architect regardless of whether he views himself as what Horst Rittel (1972) calls the doctor planner, the egalitarian planner, the needs planner, or the decisions planner.

Consider two other examples of what can be viewed as the design of shelter: the design of automobiles and the design of clothes. In the case of the automobile most of us will agree that we personally do not know enough about combustion and mechanics to design our own cars. While exceptions like the Sunday mechanic and amateur car racer exist, most of us are satisfied with the existing selection of foreign and domestic cars, whether we view the automobile as a means to get us from here to there, as a status symbol, or as an extravagance. Therefore our participation in design is limited to supporting political lobbies to force Detroit to make cars safer.

Clothes in some respect are at the other end of the spectrum inasmuch as I am confident that you and I can design and make our own clothes if we have to or want to. But clothes, unlike cars, require simple tools and involve materials that are generally easy to manipulate. At the same time, the low capital investment in materials and the high volume of the market allow for so many different kinds of clothing that anyone can find articles both that he likes and that are relatively unique within his circle of acquaintances. Note that our concept of "fit" is not demanding (most women's dresses come in only sixteen basic sizes). When we are fussy we can employ a tailor to make our clothes fit better though not necessarily to be better designed.

Houses are somewhere between clothes and cars. They are not as expendable as shirts but are more manipulable than cars. There is a greater variety of kinds of houses than of cars, but any city offers less variety than the most meager haberdasher.

The questions of this chapter focus on housing (which represents 85 percent of the built environment). The general thesis is that *each individual can be his own architect.* The participation is achieved in association with a very personal computing machine. Somewhat in contrast to Yona Friedman, I believe that a "learning period" with such a machine would be necessary, during which the machine would not make judgments and decisions but would ask telling and revealing questions and attempt to understand what *you mean.*

Three Attitudes toward Participation

There exist three quite different perceptions of what user participation really means in architecture or to architects. I will list the views in an order that moves progressively further away from the notion of a trained architect as "expert."

The first attitude is epitomized by the often heard comment: "We need more information." This is usually characterized by a program to solicit more complete information about what future users will need and want and what they have as present attitudes toward their residential environment (Sanoff and Sawhney, 1972). The attainment of such information is usually followed by "scientific" methodologies for manipulating and overseeing the new wealth of information in a manner that most effectively reveals kernels of truth, generalizations, and invariants. Conclusions are evaluated in terms of the probability of success and are exercised with, for example, computer simulations and "enhanced decision making" techniques. The architect, by reason of his training, is still the final judge of design alternatives. "There are better and worse ways to pursue design objectives. As professionals we are supposed to be experts in design. Otherwise we are nothing" (Rubinger, 1971). Or: "I would suggest that the most important area is that of social design; i.e.: the design of institutions and the deliberate control of life style, which so far seems to have been inherited . . ." (Jones, 1971).

A second attitude toward participation, almost equally protective of professionalism, is focused upon fiscal and political mobility; it is often called "advocacy planning." My interpretation of advocacy planning includes generating enough leverage for the neighborhood group, for example, to be heard and seriously considered by planners and architects in order that their needs will be reflected in plans for renewal and development. This is usually implemented in the form of a professional person or persons urging a body of "decision makers" on the behalf of a certain larger group; it is rarely the case that the individual citizen gets more than the most indirect poke at a plan. He is usually appeased with minor forms of self-government: operating the local welfare establishment or attending a PTA meeting. Or, in the context of building, he and his kids might have the opportunity to participate in the building of a playground.

The third approach, the Yona Friedman paradigm, is to go all the way, removing the architect as translator and giving the inhabitant what Wellesley-Miller (1972) rightly calls control. In short, each person becomes his own architect. He is forced to become intimately involved with viewing the consequence of one alternative versus another. The analogy put forth by Yona Friedman (1972b) is illuminating: Consider an illiterate society that had only a few public writers who, perforce, would be required to employ printed standards when writing personal letters for all the individual clients. In contrast, the public writer could be eliminated by public education.

I propose to set aside the first two approaches; I do not consider them serious forms of participation. They are timid endeavors of deprofessionalization, and they have in common the retention of a new kind (perhaps) of expert or, to use Goodman's (1972) term, a "soft cop." The third approach, on the other hand, is a do-it-yourselfism that completely removes the architect and *his* previous experience as intermediaries between my needs (pragmatic, emotional, whimsical, etc.) and my house.

It should be noted that this third approach cannot be easily examined in the context of today's urban landscape. We have very little precedent, for example, of physical shifts taking place continually, on a day-to-day or week-to-week basis, in the way this approach might afford. At the same time, it raises some very serious issues like: Would people really want to design their own homes? What are the advantages of designing versus choosing? Are we losing positive inputs by removing the personal previous experiences of the human architect? How do such experiences differ from conceivable machine experiences? Is this really an architecture without architects, or are we really implying a new breed of surrogate architects?

Paternalism, Middlemen, and Risklessness

When I graduated from architecture school I sincerely thought that I knew better how others ought to live; I knew this as a result of my five years of training. After all, in school we studied methods for supporting "life styles," articulating "patterns of living," and educating the unaware citizen. It did not occur to me that upon entering practice and in the guise of peddling an expertise, I would in fact be foisting my values upon others. It would not be a case of reckless autocracy; rather, it would be a pervasive and evasive set of restrictions that would result from the good intentions of being comprehensive, orderly, and empirically correct.

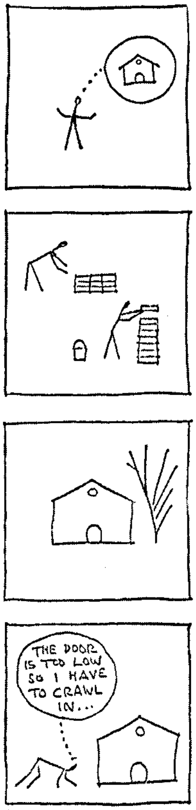

Figure 23.3.

The story of Mr. Smith:

I had an idea about my house.

I translated my idea into bricks.

This is my house, the result of my "translation."

I made a mistake in translating, which I did not discover until I used my house.

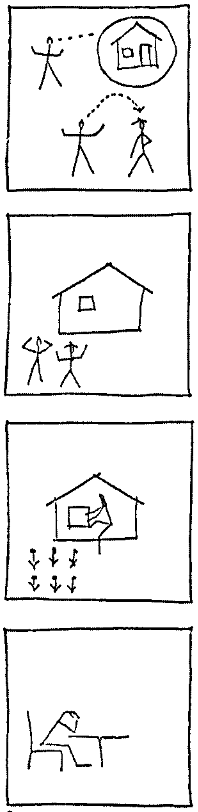

Figure 23.4.

The story of Mr. Wright:

I had an idea about my house, and I explained it to the builder.

The builder misunderstood me. The result is that my house has no door to the garden.

Every time I want to use the garden, I have to get there through the window.

My mistake was in not explaining more explicitly to the builder what I wanted him to build for me.

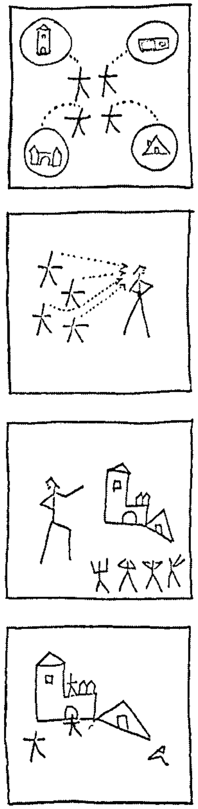

Figure 23.5.

The story of a neighborhood:

Each of us had an idea about his house.

We tried to explain our ideas to an architect, but there were so many of us that there was not enough time to explain our ideas sufficiently.

The architect translated our ideas into an idea of his own.

He liked his idea but we did not like it.

And it is we who have to use these houses, not the architect!

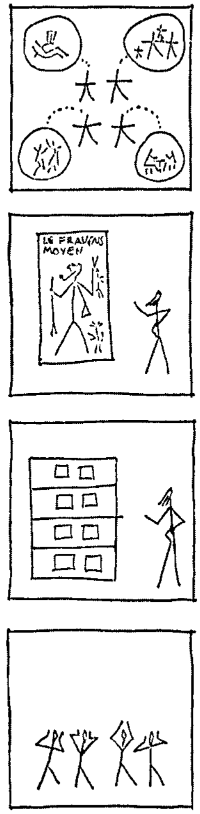

Figure 23.6.

The story of another neighborhood:

Each of us had his own idea about how to live.

Our architect did not listen to us: he knew everything about the "average man."

The apartments he built were designed for the "average man."

But we are real people, not average at all. We are not comfortable living the way our architect likes to live.

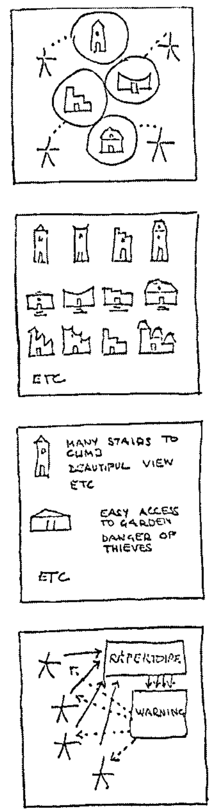

Figure 23.7.

A different kind of story:

Each of us has his own idea about his house.

Fortunately, there is a repertoire of all possible houses. Fortunately also, there are instructions about what to expect from each kind of house.

Each of us can make his own choice, using the repertoire and the instructions.

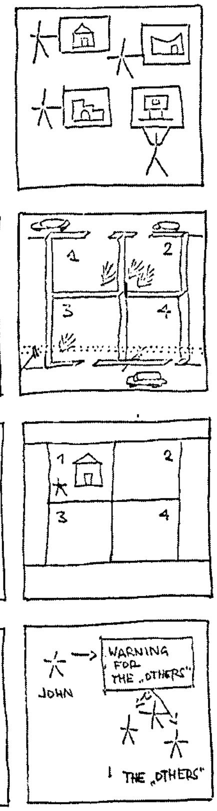

Figure 23.8.

Each of us can thus plan the home of his choice, based on his own idea.

In order to build our homes, we each need a lot, an access road, a water main, a power line, and so on. This is the infrastructure that supports each house.

John wanted to build on lot 1.

The others agreed . . .

. . . After making sure that John's choice of location did not hold disadvantages for them.

Here the stories end.

I remember one professor telling me that architecture is a form of social statement, that any building I ever designed ought to be the manifestation of profound symbolic comment. Isn't that both presumptuous and irresponsible, and, to say the least, paternalistic? While such attitudes may be applicable in a special context of building, I propose that they are generally inappropriate and a frequent cause of unresponsive architecture. The problem can be phrased in a simple question: Can an expert have expertise in goals and values, or is expertise *per se* limited to means?

Father knows best for a long time. However, after a while he begins to lose credibility rapidly. Inconsistencies and unexplainable "musts" make the original institution of paternalism more and more suspect to a child; the doubt probably starts as early as age one or two. Nonetheless, for a long time the issue of Father's rightness is less important than the comfort of knowing he is around. In this sense, it is interesting to question the role of the architect in terms of comfort and confidence; can it be embraced in a machine and thus avoid the potential orphanage of participation?

Another question: If the architect as middleman is translating your needs in a built environment via transformation procedures seasoned by wisdom and his ability to "pre-experience," what side effects and distortions take place in the process of this interpretation? How much of the deformity is positive in, for example, generating goals that you would never have thought of yourself? What do we lose when he goes away? Can a computer provide it?

As a last question, consider the issue of risk. Can you seriously trust that someone who has no ultimate personal stake in the built artifact will do his utmost to achieve your personal and complex goals? An impelling motivation in most labors is in the consequence of doing a bad job. In contrast, the architect is released from all risk after his particular chunk of the built environment is built. The hazard to his reputation is slight, for he will be judged by colleagues and observers who do not have to live in what he has built and who will use extraneous criteria as the basis for criticism. In other words, the architect gets off scot-free, as innocent as the author of a bad novel.

Indigenous Architecture as a Model

Positano, Mykonos, Gasin, and Mojacar are typical sites of an indigenous architecture that has fascinated and held the admiration of architects. Rudofsky (1964) provides a wide-ranging set of illustrations that dramatically display an "exciting" architecture, which is specifically the result of citizens designing and building their own homes. This has been achieved without the help of architects, explicit master plans, or explicit zoning (or computers). How did it happen?

At first glance, most indigenous architecture appears to be the result of purely "local" activities: a house added here, a path extended there, and so on. However, upon examination one finds "global" forces, which act in a very real sense as elements of town planning and which ensure an overall unity. Typically these are found in the availability of building materials; for example, a locality that lacks timber achieves spanning by means of masonry domes, or one that lacks stone limits its structures to one or two stories. In other instances, these forces are found in climatic conditions, manifest most obviously in the whiteness of houses to reflect the heat, less obviously in the purposeful crookedness of streets to break the wind. In still other cases, the unifying forces are compelling traditions, which often support building conventions that had previous (but now defunct) environmental causes.

Forces such as these are the basis of a "vernacular." They provide a unifying pallet of materials and design conventions, what Friedman calls the "alphabet" of the "language." They act much in the same way as the proposed information process of Friedman (1971):

"With the elimination of the designer (the professional one) from the design process—by vulgarizing the 'objective' elements in the process, and by introducing a simply understood feedback concerning potential consequences of individual decisions on the whole—the paternalistic character of the traditional design process will disappear. The enormous variety of emotional (intuitive) solutions which can be invented by a large number of future users might give an incredible richness to this new 'redesigned' design process."

How can we simulate (if we want to) these conditions in an industrialized society? Strict zoning, more severe building codes, one building system (imposed by law), or a regulation that you must use brick are certainly not the appropriate measures; they lack the subtlety of natural forces within which a richness is conceivable. The answer must lie in the so-called "infrastructure," a mixture of conceptual and physical structures for which we all have a different definition or interpretation. I refer the reader to Yona Friedman's two most recent books: *Realizable Utopias* (1973) and *Society=Environment* (1972). And while I am continually alert to the need for such subtle but preponderant forces, for my purposes here I would like to assume an infrastructure composed of a resilient building and information technology and ask what role there might be for a machine intelligence acting as a personal interface (not translator) between this infrastructure and my ever changing needs. I recognize it is a big assumption.

Before venturing a machine intelligence position, I would like to examine the indigenous architect as an archetype and to scrutinize his behavior beyond commending his picturesque results. He did not need an architecture machine; his environment was simple and comprehensible, punctuated with limited choices and decisions. He no more needed a professional architect than he needed a psychologist or legal counselor. To understand him, let us consider three representative (but not categorical) features of indigenous architecture.

The first is the naming of spaces. In this sort of architecture, the rooms tend to be about the same size, often as large as the technology or timbers will permit, and they rarely have names. A place to eat is often somebody's place to sleep, and cooking is frequently done in more than one room. This implies that a multiplicity of activities can be conveniently housed in similar spaces, and there is very little generic meaning to "bedroom" or "living room." The generics seem to reside in "sleeping" and "eating" and "cooking," and we can extrapolate (tenuously perhaps) that they have a *large common intersection,* larger than we tend to believe.

A second feature that deserves comment is the apparent ad hoc growth of the dwelling unit. Usually a dwelling unit is limited to a small number of rooms and might be added to in the event of offspring. In Greek island societies the dwelling is passed down as dowry; a larger house is often divided in two and the boundary allowed to oscillate between the shrinking of one generation and the growing of another. Rooms are frequently passed to a contiguous house, entrances sealed and opened as required. These local expansions and contractions result from a permanency of home with which most Americans are unfamiliar. In an industrialized society, the pattern is to sell your house and buy a bigger one, then later, a smaller one. I can remember (but not reference) the statistic that the average American family moves every three years.

The third observation, perhaps the most important, comes from my personal experiences of living on an Aegean island. It appears to be true that the local residents of an indigenous environment are unanimously dissatisfied with their architecture. Glass slabs are their metaphoric goals as much as, if not more than, the little white stucco house is mine. My electric typewriter has as much meaning as a Byzantine icon. Perhaps this can be explained in terms of communication technologies, by arguing that the local resident would be content, at a level to which we aspire, if he had not witnessed the electric toys of our times through magazines, television, and the passing rich tourist. However, a more deep-seated issue is the breadth of experience shared among these people. It is the case that they have in fact had very similar experiences among themselves and consequently carry nearly similar metaphors and share personal contexts. I am not saying that individuality has been squelched; I propose that the spectrum of experiences is small and may be accountable, in part, for this dramatic level of participation, so far not achieved in industrialized societies. It is quite clear that in faster-moving societies our personal experiences are phenomenally varied. This is why we have a harder (if not impossible) problem. This is why we need to consider a special type of architecture machine, one I will call a design amplifier.

Design Amplifiers

Before I begin I feel obliged to tell you that The Architecture Machine Group has worked very sporadically and without much success on this problem. The notion of a "design amplifier" is new and might provide an interim step between the present and the wizard machine, the surrogate human. I use the term "amplifier" advisedly; my purpose is not to replicate the human architect, as it may have been five years ago, but to make a surrogate *you* that can elaborate upon and contribute technical expertise to *your* design intentions. This allows us to consider and possibly see in the near future an option for computer-aided design that presumes "informed" machines, though not necessarily a machine intelligence.

There is an inherent paradox here. A design amplifier will have no stake in the outcomes of joint ventures; hence it must act truly as an extension of the "future user." Does this

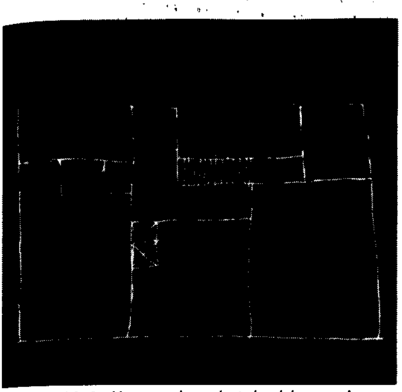

Figure 23.9. House plan sketched by novice.

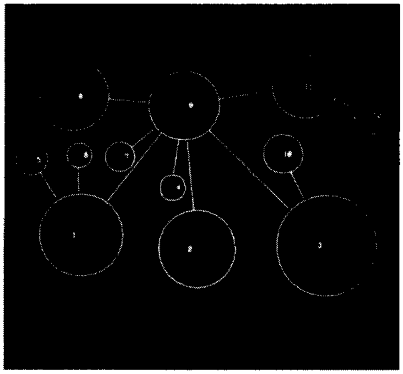

Figure 23.10. Mapping of preceding house plan into planar graph.

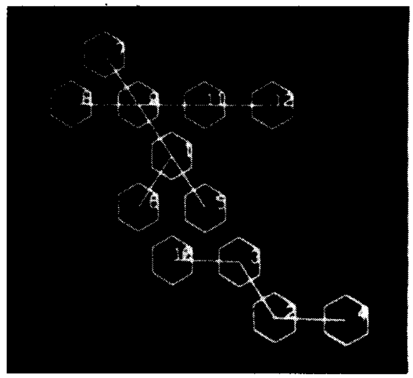

Figure 23.11. A hexagonal resolution of the graph.

in turn mean that the machine intelligence necessary to support richness of dialogue will in fact be counterproductive to the participation because this same intelligence, like that of the human architect, would fall prey to the ills of translation, ascribing meanings of its own? In other words, does the intelligence required to communicate contradict the notion of informed amplification? I would draw your attention to the analogy of a good teacher who fosters an intellectual environment in which you discover for yourself in comparison to the one who drills facts and proclaims principles. As such, let us consider aspects of a design amplifier in terms of a somewhat dual existence: the benevolent educator and the thirsting student, all in one.

There are two categories to consider: (1) What does the machine know? (2) How does the user deal with what it knows? These questions are particularly interesting because the most obvious paradigm is in fact the least rewarding. The most obvious method would be to construct a machine with a vast knowledge of architecture and to view the user as an explorer of this knowledge through a window of his needs and the medium of some sophisticated man-machine interface. An example of this is found in most computer-aided instruction systems where, for example, the machine *knows* arithmetic and the child manipulates the machine in a more or less prearranged exploration, witnessing *yeses*, *nos*, *dos*, and *don'ts*.

A more exciting approach applicable to a design amplifier can be found in the recent work of Seymour Papert (1971a, b, c) and his colleagues. In brief, their theory is that computer-aided instruction should be treated as the amplification and enlightening of the processes of learning and thinking themselves, rather than merely presenting and drilling specific subject matter. To achieve this, the computer is treated, in some sense, as an automatic student *by the child* (see also Ackoff and Emery, 1972). In the Papert experiments, the six- or seven-year-old youngster has the opportunity to give a "behavior" to the computer via a simple but powerful programming language called LOGO. Whether

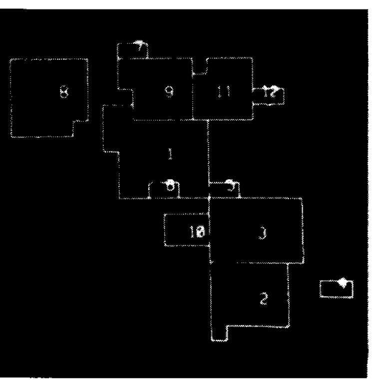

Figure 23.12. House plan generated from 11.

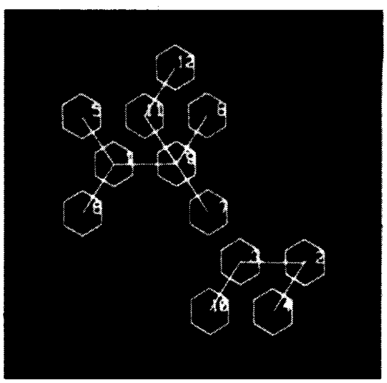

Figure 23.13. Another alternate graph.

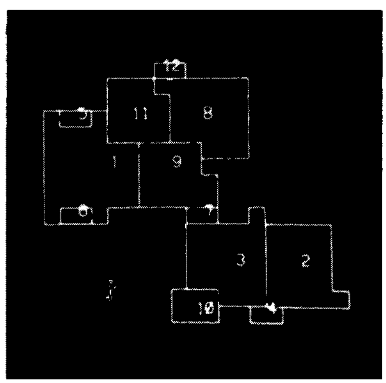

Figure 23.14. House plan generated from 13.

the behavior is to be manifest in reversing a string of characters or having a turtle draw a polygon, its misbehavior reveals "bugs" and, most importantly, contains cues for ameliorating the system. The child observes the process by which he learns, and the notion of *debugging* is suddenly put in contrast with the penalties of *error making*. Furthermore, the child is learning by doing (by playing). "You can take a child to Euclid but you can't make him think" (Papert, 1972).

If you are an architect, how many times have you heard, "Oh I wanted to be an architect but was no good at drawing" or "I wanted to be an architect but was terrible at mathematics"? If you are not an architect, have you ever said something like that? In the same way that your saying "I am no good at languages" is contradicted by your living in France and learning French (or in the case of math, having Papert's mathland), one can consider a designland where one learns about design by playing with it. The underlying assumption is that, while you may not be able to design an efficient hospital or workable airport, you can design your own home, better than any other person.

You already choose furniture, paint walls, and select decors for your house. If the building technologies supported the notion, what knowledge would you lack in order to move up a scale to allocate space and decide boundaries between indoors and outdoors? Or, to pose almost the same question another way, What does an architect know that a contractor doesn't? The answer may be found by briefly partitioning the design process, separating what you might call talent from competence (an apprehensive but telling disjunction). The ensuing argument is based upon the assumption that the symbiosis between future user and machine is so strong that "talent" is in the eyes of the resident and competence in the hands of the design amplifier. This is in dramatic contrast to previously stated (by me) positions!

Note that comfort and confidence (and credibility) embrace a recognizable competence. Aside from a profound knowing of the user, there are certain operational "expertises" that can oversee interrelationships measured in such terms as British Thermal Units, kips, or feet per second. In a very real sense, these are simple computing tasks and, beyond correctness (which is simple), the checking must reflect only timeliness (which is not so simple). The closest I can come to a design amplifier is URBAN5, which did have "competences" and did try to effect a timeliness in the surfacing of what we called conflicts and incompatibilities (Negroponte and Groisser, 1967a and b; 1970). However, it should be recognized that URBAN5 was the ultimate paternalist; it suffered from (among other things) being directed to serving the architect, not the resident.

Two Loops

Following Friedman's simple model of two loops, one with me and one with my neighborhood, let's examine some aspects of each in terms of automation. The reader should refer to the extensive works of Friedman, found in the bibliography, but should be cautioned about the particularly French notion of a "*banque de données*" or what he calls "a repertoire." It is somewhat misleading taken at face value because it assumes a menu-picking activity rather than a design activity. The offerings of a menu of solutions obviously cannot exceed the combinatorial product of the parts (which may be enormous). Friedman, unlike many researchers in France, escapes this particular constraint by making his repertoire (*banque de données*) contain topologies that do not have a metric. It is the user's adding of this metric that affords the limitless variety.

The first loop is private. It must be self-sustaining in its powers to maintain the user's attention, ask intelligent questions, and provide broad commentary. It must tread the thin line of distinction between making suggestions and being a bully, between criticizing and insulting, between navigating a search and directing it. Friedman (in personal conversation) makes a distinction by calling the computing organism a "consultant," implying a "knower" at your beck and call, paid to help even if he may not agree with your personal premise. The connotations of *consult* are illuminating in the sense that the underlying skill is uncluttered by metaphorical distinctions, but it is also disturbing inasmuch as one must seriously question whether proficiency can be shared without dialogue requiring metaphor.

The closest example of the first loop implemented in a computer program is ARCHIT (Rorick, 1971). The following is an excerpt from one conversation.

> Computer: Shall we discuss the dining areas?
>
> User: Yes.
>
> Computer: Who does most of the cooking in your family?

User: Carol.

Computer: I would suggest that the dining area for your everyday meals be in the same room as the cooking area so that everyone can socialize while meals are being prepared and Carol won't be isolated in the kitchen. Don't you agree?

User: Yes.

Computer: How often do you want these occasions to be formal (that is, other than casually joining you for dinner) in times per year?

User: 12.

Computer: Keeping these answers in mind, do you feel that you need a separate dining area for more formal occasions?

User: No.

Computer: How many people do you want the everyday dining area to accommodate including company?

User: 8.

At this point the reader should be appalled. The computer program has browbeaten the user into not wanting a dining room and short-circuited the deeper patterns of living that may keep Carol in the kitchen quite happily away from everybody. The program has exhibited an illusion of intelligence and "knowingness" and, in this example, done all the talking! Unfortunately, I do not have a more positive example to offer (but am working on it). A blatant flaw in ARCHIT-like programs is the desire to rapidly pinpoint an "architectural program" via direct yes/no, one/two questions. Inference making and indirect procedures should be used, not for the purpose of making life difficult (for the computer), but for the purpose of soliciting more complex and revealing patterns of living. We must avoid initiating dialogue by asking questions because the questions perforce flavor the answer. The next section describes a simple experiment in inference making, one that avoids asking questions.

In contrast to the "inner" loop, the "outer" loop is a great deal easier to conceive. Its purpose is to flag local perturbations when a desire of mine conflicts with an amenity of yours or of the group at large. A simple example would be a construction of mine blocking light or view from a portion of your house. Such functions assume that the machine is all-knowing about geometry, particular desires, and complicated rules (which is relatively easy). It also assumes, like any law-arbitrating system, the ability to exercise rules in context (which is not so easy). In managing urban spaces we already have the example of zoning ordinances and the vicissitudes of seeking variances.

The general scheme would be a network of many (one per person) design amplifiers working in concert with a variety of larger "host" machines, machines that could direct questions to other amplifiers or could answer those related to more global matters. An advantage of this layout is the opportunity, hitherto impossible, for personal negotiations within a regulatory framework that could capitalize upon the special-case amenities that are important to me and are available for negotiation. For example, my roof surface could serve as your terrace without inconvenience to me because it happens to be above services and functions that would be disturbed by noise. Or, I might not mind your cantilevering over my entrance, as the reduction in light would be more than compensated by the additional shelter I happened to want. While these are simpleminded examples, they reflect a kind of exchange (even bargaining) that is not possible in present contexts. They assume two parties, but this could be extended to complex and circuitous tradeoffs: if $A \rightarrow B$, $B \rightarrow C$, $C \rightarrow D$, . . . , $\rightarrow n$, $n \rightarrow A$. We begin to see the opportunity for applying three-dimensional zoning standards and performance standards in context, a feat that I propose is manageable only with a large population of design amplifiers that could talk to each other and to host machines.

Plan Recognition

A typical exercise in computer-aided design is the generation of two- and three-dimensional "layouts" from a set of well-specified constraints and criteria. The classical and most recent experiments can be found in Bernholtz (1969), Eastman (1972), T. Johnson et al. (1970), Liggett (1972), Mitchell (1972b), Mohr (1972), Quintrand (1971), Steadman (1971), Teague (1970), Weinzapfel (1973), and Yessios (1972). The underlying and common thread of all these works is the framework: input of "problem specification" and output of physical description. This section considers an experiment that seeks to do the reverse: input of a physical description (through recognition rather than specification) and output of problem specification. The goal is to recognize a structure of relationships and attributes in contrast to asking for a description.

In the context of participation, the purpose of this experiment is to initiate a dialogue by raising issues (not necessarily questions) drawn from inferences derived from a plan of the "user's" present house. Preceding sections and previous chapters suggest a profound man-machine acquaintance, one that would take a long time to achieve, perhaps years, and one that would have certainly a much wider application than assisting you to be your own architect. In the same way as the machine intelligence paradigm is self-defeating, the acquaintanceship approach to dialogue also could stymie progress and impede initiative in that it is difficult, if not impossible, to seriously consider a modest experiment without ending up with goals to match human dialogue and friendship. The following experiment is a sample point of departure and, as such, it should be viewed only as a mechanism that will lead to conversation, not as a means of generating house plans. The prime feature of this approach is that it can remain silent and attentive at first (without "tell me this," "answer that," "say this," etc.), can timidly venture comment, and then can vigorously interact (if all goes well). This is in contrast to the otherwise necessary tedium of questions and answers that must be employed to immerse the user and to introduce the machine.

In this experiment the user is simply invited to draw a plan of his house. He does this with ballpoint pen and regular paper without the burdensome paraphernalia of most computer graphics (the hardware is described at somewhat greater length in Appendix 1). It can be arranged that the user be completely unaware of the attention or observation of the machine. Remember that the user is not an architect and probably draws very badly; he may very well have never drawn a plan of his house before. It is interesting to note, however, that the most inexperienced sketcher suffers from the lack of two skills, neither of which really matters (at first): (1) He is bad at maintaining constant proportion and scale, as exhibited by his inevitably running off the side of the paper. (2) He is not sure-handed enough to draw straight and forceful lines. However, he is, curiously enough, extremely adept at describing physical relations and juxtapositions, from which we can extract adjacencies and linkages and can construct, for example, graph representations like the planner graph grammar used by Grason (1971).

The initiation of the dialogue is achieved by mapping the physical plan into a relational structure (like the adjacent graph in figure 23.10) that does not have a metric (hence the initial unimportance of scale). The structure then is used to generate other solutions, assuming that the structure is underconstrained as a result of recognizing only a subset of the relations. It is much like only half-listening to a story, extracting an incomplete theme, and developing a new narrative (with similar structure). The other plans (that is, the machine's story) reveal physical arrangements that have enough commonality for the user to make interested comments and for the machine to pose interesting questions. *Interesting* is defined here as leading to an increase in the user's realizing and understanding architectural implications and an increase in the machine's apprehension of the particular needs and patterns as manifest by what the user has now.

The plan recognition program, SQUINT, employs the services of HUNCH. In particular, it exercises the feature of zooming in and out of the positional data, traveling within the spectrum of very low and very high resolutions. The preceding chapter illustrates the sort of range; the grain varies from 1,024 rasters per grain to a one-to-one correspondence. And, at any grain except the finest, the percentage of "hits" can be viewed as a gray tone.

As happens with HUNCH, the noble intentions of SQUINT become reduced to very straightforward operations. Simple properties are recognized from the limiting boundaries of spaces and the penetrations of the boundaries. The first step is to look for the total number of bodies in the sketch. While there is usually one, this initial observation is necessary, if for nothing else than to save memory by compressing the positional data to exclude the "white of paper" that lies outside the sketched plan. The recognition of discrete bodies is achieved by a "flooding" process that creeps in from the sides of the paper, flowing around obstructing lines at a grain appropriate to ensure that it does not seep through doors and windows. Subsequent to flagging all flooded bits, the remainder are accounted for in a similar flooding technique, starting at any point. If all points are not accounted for by the first two floods, then there must be more than one body, and the procedure needs to be repeated until all points are tagged. It is the responsibility of later routines to decide whether the multiple elements in fact represent two autonomous disconnected sections of a house, for example, or whether in reality the additional figures are diagrammatic elements: north arrows, lettering, doodles, or coffee stains.

Following the location of the silhouette(s) of the plan, rather similar procedures wander through internal subdivisions from one space to another, at one grain or another, a little bit like an expandable/shrinkable "mouse" meandering through a maze. Most sketching techniques will allow for internal spaces to be attained at the finest resolution. However, some sketching techniques include the demarcation of door radii and steps, which would impede passage of our "mouse" if the lines were considered boundaries (which they are not). These are the interesting cases; one must look for cues and develop evidence that, for example, such-and-such is probably a tread and not a chimney flue or this is probably a jamb and not a sill. Some of these situations are particularly difficult to deal with, where, for example, in one case the misinterpretation of a one-step level change resulted in guessing that the entire circulation of the house passed through the guest closet. This extreme example may appear to be a violent programming oversight. I must repeat, however, that there will *always* be conditions of such ambiquity that will require even the onlooking human to ask. I further insist there is nothing wrong with asking!

Irrespective of whether the user has ascribed names to spaces, the program will give its own names in order to have an internal nomenclature of nodes and links. The labels can apply to traditional names (if you insist) like "bathroom" and "bedroom"; to orientations like north, windward, or view-oriented; or consist of schematic titles like space A, B2, or 732. The labeled nodes of the structure are linked with either categorical *yes/nos* or graded values of an attribute like access/circulatory, visual, acoustical.

The subsequent mapping into an alternate floor plan has been done by Steve Handel and Huck Rorick. Rorick's experiment appends the somewhat extraneous but interesting feature of adding heuristics that represent his view of what another architect might have done. In the specific case illustrated he has developed heuristics for overlaying a third dimension upon the plan following the vernacular of Frank Lloyd Wright, generating a variety of Wrightian roof forms. Though this is contradictory to the full level of participation suggested by Friedman, it is fun to speculate that a representation of a deeper structure of my needs could be manipulated and displayed in the formal jargons of various famous architects, perhaps even Vitruvius or Viollet-le-Duc.

We should not forget that the user of "computer-aided participatory . . ." is not an architect. "Plan recognition" might imply to some a more formal approach than is intended. The reader should be referred, if he is interested in the morphologies of floor plans, to the original works of Levin (1964), Whitehead and Eldars (1964), Casalaina and Rittel (1967), and the most recent work of Weinzapfel (1973). However, remember that these systems assume the driver to be an architect.

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