AN IDIOSYNCRATIC SYSTEMS APPROACH TO INTERACTIVE GRAPHICS

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Abstract

This paper applauds and emphasizes the Workshop's title, "User-Oriented Design of Interactive Graphics Systems," but bemoans and condemns its subtitle,+ "Application-Specific User Behavior and Cognition." The pros and the cons are an incomplete but cogent case for consideration of an *idiosyncratic systems* approach to interactive graphics systems.

An idiosyncratic system is a personalized system. Personalization means both recognition of and response to the complete range of an individual's characteristics, from physical traits, to work habits, to cognitive styles. Enough evidence exists in the literature of experimental psychology to substantiate the fact that user behavior is not application-specific, but driven by personality and experience. The resulting criteria for a user-oriented interactive graphics system include existential hardware, adaptive representations, inferential input, and graphical conversation.

*Work reported herein has been jointly sponsored by the National Science Foundation (Grant: DCR74-20974-A01) and the Office of Naval Research (Contract: N00014-67-A-0204-0074). Mention is made of touch-sensitive displays, which is work in our laboratory, currently sponsored by ARPA (Contract: MDA903-76-C-0261).

+Editor's Note: See Part IV.

Introduction

When computer graphics emerged in the early sixties (1,2) it appeared as a highly interactive process for man-machine communication. However, for the following decade, it developed as a predominantly static medium, finding less application than anticipated. I can see three reasons for this curious development:

1. The concurrent development of time sharing, which was a bad host to graphics. The remedy, storage tubes (3), further entrenched the notion of static graphics.

2. A vast infusion of research funds allocated to computer graphics research at the University of Utah in the middle sixties. That work was particularly inbalanced toward the picture-making prowess of computers and their programmers.

3. Refresh display technology was too costly to justify.

Currently we see many changes which are bringing computer graphics out of this static era, back into worlds of intensive interaction between user and machine. I offer the following four explanations for this change:

1. Hardware costs are dropping, disqualifying some of the premises of time sharing, offering cost-effectiveness in minicomputer technology, allowing high-bandwidth interaction with mass memories. We are told that the megabit memory chip is not far off (4).

2. Consensus and movement toward raster scan displays in general and video in particular (5) offer a new refresh display technology, one accompanied by new dimensions of halftone, greytone, and color.

3. Attention is being directed to the previously ignored problem of graphical input (6,7), for example, touch sensitive displays (8).

4. There has been a broadening of the community of users and enthusiasts, previously self-serving, frequently caught in the quagmire of data structuring.

The result of these four circumstances is a revewal and momentous interest in interaction and the application of the hitherto freakish medium of computer graphics.

The renewed enthusiasm for interactive graphics is part of a more general trend toward what Winegrad (9) calls "The Peoplization of Computers." Interest in how people might best use and be best satisfied with computers is ushering in strategies for satisfaction based for the most part on a "human factors" approach to design. By this I mean that systems designers are searching for guidelines to achieve, in the case of computer graphics, more comfortable keyboards, more practical pens, more effective display formats, and to orchestration of more dimensions of the medium (notably color). I hear questions that begin with, "Why do people direct their attention to...," "Do people prefer color in...," "Are people less eye-strained with...." These examples illustrate my point of contention: people (the almost-plural of "person"). "User-oriented" is neither plural nor singular in fact, but plural in spirit, and that is our problem.

The theme of the following sections can be called "person-oriented interactive graphics," "person-oriented" in the most singular sense of made to order. I will argue that we are all so different in our manners and mannerisms, in our thinking and thoughts, that we need highly personalized computers and computer interfaces, not only to cater to our individuality, but to amplify it. A seemingly reckless but instructive stance to keep in mind is that in the future the only reason to use computers might be for the purpose of being creative. I suggest this extreme not as an exercise in narcissism, but as a tenet for measuring how interactive graphics is enjoyed, not by measuring a person's productivity, but his or her perception of it.

The Both/And Attitude toward Design

Societal and social fabrics are too frequently woven by either/or decisions: guns or butter, shut up or put up. We are told that we cannot have our cake and eat it too, usually because (with computers) it costs too much. But cost is not really the driving factor of this attitude. It results from a misguided search for "bestness," as if bestness can survive more than moments and can be normalized across a community, profession, or culture. We have a formidable body of literature in experimental psychology devoted to the identification of the normative behaviors of people. Authors will argue that meeting these norms is on the road to success. Ultimately, on a statistical basis we adopt one implementation over another by making a handful of either/or decisions. And it seems to work because we can never tell if the human variance would have been signal or noise because of the amazing adaptability of human beings in covering for error.

I contend that if a system is to be person oriented, that person should at least design it and should be able to change it at a moment's notice. Leaving the term "design" unqualified for a moment, this means that the computer scientist or manufacturer must champion a both/and attitude in what they provide. In the specific case of computer graphics equipment, I shall call these kinds of designs existential hardware.

I am not suggesting that we make keyboards for Brobdingnags. I am comfortable with the hypothesis that a finger is .5 inches in diameter, plus or minus something, but not an order of magnitude. I am struck, however, by the scope of certain individual differences, where, for example, a study of the time taken by computer programmers to complete a standard program showed a range of 2300 percent (10). And I am horrified by computer graphics' disinterest in something as simple as right- and left-handedness, and the resultant repositioning of function keys or light buttons. A marvelous exception, and the closest I can come to exemplifying the notion of existential hardware, is Ken Knowlton's keyboard for telephone operators.

Briefly, with the combination of a color raster scan display, a half-silvered mirror, and a virgin keyboard, Knowlton orchestrates and lets the operator reorganize over one thousand keystrokes. Knowlton uses color, position, intensity, and transiency to:

1. prune the tree of decisions
2. offer a redundancy of cues
3. allow simple personalizations like putting the 10 key digit set on the left, if you are left-handed.

This is an example of existential hardware and the both/and attitude. How many times have we heard that tactile feedback is important to keystroking, but that changeable keys can only be achieved on touch sensitive displays or with light buttons? You either have the satisfaction of typewriter or you poke or point at a piece of glass. Knowlton has both/and: complete tactile interaction and changeability (by the way, with no parallax). Additionally, he offers the interesting feature of seeing through your hands!

To begin thinking about similar implementations in computer graphics, we must start by forgetting current display technologies and input devices. Instead, let us consider some of the properties of blackboards, bulletin boards, paper, pencil, chalk, and even the organization of our own desk tops. While not interactive domains in themselves, they do afford very important spatial and temporal organizations, important to memory schemes, to working priorities, to personalization, and to what I will call "ambient information." In complete contrast, consider the notion of a "window" in computer graphics. In both the logical and literal sense, it is a porthole to a multidimensional data space, viewed by panning and zooming. I liken this window to the blinders on the horses which anachronistically pull carriages down Fifth Avenue. Instead, a both/and approach can be characterized as a filter, not a window, within a surround or milieu (11). I suggest a computer graphics place.

Several researchers are working on the so-called "electronic desk." While this work epitomizes the race toward a paperless office, some deference is being shown toward paper (12), particularly in a RAND memo "Don't throw out the message with the medium." With paper, characteristics of crumpledness, yellowishness, coffee versus whiskey stains, indicate dimensions of age, reader interest, completeness, and the like. This says nothing about scribbles in the margins that can range from important revisions or questions, to haphazard doodles, to important but unrelated shopping lists.

One image of the both/and attitude applied to computer graphics is found in the thinking of Zelikovitz and his colleagues at Bell Northern Research in Canada (7). They imagine a very high resolution, volatile display medium, large enough to be a surrogate desk or real wall, first implemented (perhaps) through projection techniques. Billions of pixels would be available for the user to arrange in any fashion, not unlike scattering note pads of various sizes across the top of a desk. One is reminded of how often we rotate our pads to draw vertical lines with "horizontal" control. Similarly I would expect to use my left hand to rotate one of my displays in order to draw more conveniently.

Adaptive Interactive Graphics

While user participation in the structure and arrangement of a display or input format is a necessary criterion for an idiosyncratic approach, it is not sufficient. Additionally, the system must be adaptive. That is, it must automatically do some of those things available for the user to do. This is a touchy subject.

In my first treatment of idiosyncratic systems (13), I used the following example, taken from a hypothetical husband-wife scenario, to illustrate the results of adaptation, in the case of inference making:

> "Okay, where did you hide it?"
> "Hide what?"
> "You know."
> "Where do you think?"
> "Oh."

More graphical examples can be found in

numerous references to the problem of sketch recognition, most recently Herot (14), Taggart (15), Negroponte (16). They dwell on the single assumption that people draw very differently. Knowing these differences for a particular individual allows the substantiation of simple graphical intentions, like: a curve was meant, a square was intended, these overtracings mean reinforcement. A later section describes the potential use of this kind of recognition in a new sort of graphical conversation.

A final example, somewhere between the sophistication of cohabitants and the banality of line finders, can be found in problems of computer aided design. Common to human-to-human interactions in design is the problem of timing. A criticism or a suggestion is a captive of its timing. Not only does it take a good teacher to introduce a comment at the most effective time, but it takes a personal acquaintance to validate it.

All of these examples of adaptation characterize responding to the traits of an individual: habits, drawing styles, receptivity. From that individual's point of view, these are welcome features of an interaction for three reasons:

1. We only like to say things once.
2. We are very sensitive to "context."
3. We require tolerance of ambiguities, inconsistency, and incompleteness.

Sometimes we require outright error correction, without the nagging: "Didn't you mean...." A very pragmatic and eminently feasible application of adaptation can be found in the problem of spelling correction, particularly when the error is typographical (17). Knowing the typist is postulated as the prime mechanism for disambiguation. This is extremely important to interactive systems. The reader can surely remember occasions where a train of thought was disrupted totally by something like "INSRET is not a recognizable command" (an error not uncommon to one particular hunt-and-peck typist).

What makes adaptation troublesome or, as previously described, touchy, are the pitfalls of complacency degeneration, and apathy toward deviancy (18). Returning to graphical input, consider the application of sketch recognition techniques to handwriting recognition, in a manner not unlike the command recognizer proposed above. It is not difficult to imagine ten years hence, a situation where we find a community of machines unwittingly ignoring and fostering the disease of dislexia. In an era when we grow up with machines and play with machines, as well as work with them, it is not inconceivable that a pathological case of computational adaptation might be to recognize every hand-drawn 2 to be 5 and to proceed accordingly. The science-fictional threat is that we will end up in a world where a person can talk to other people only via his or her machine.

A more likely argument against adaptive interactions is that of degradation of personal skills, where, for example, a person's ability to draw degenerates into a hodgepodge of scribbles, recognizable only by a computer, and only one computer at that. This argument is as vacuous as the case against pocket calculators as threatening us with the possibility that the human race will forget how to multiply. Some intellectual functions will relax and lose acumen from infrequent use, but they will surely not be the prime ingredients of creative behavior.

The issue of instilling a new kind of complacency is, alas, application-dependent. In general it can be dealt with through what we might call benevolent antagonisms: questioning axioms, postulating new taxonomies, highlighting low-key features, and the like.

In the balance, the case for pursuing adaptive interactions remains strong and intact. Namely, an interactive graphics system really is not interactive, unless the system knows who is using it. I am again reminded of the usage and maintenance of one's desk or blackboard. A most annoying situation happens when a housekeeper or janitor wipes it clean. More satisfactory is properly selected neatening and erasure. Most exciting would be the appearance of an enlightening document or an explicative annotation.

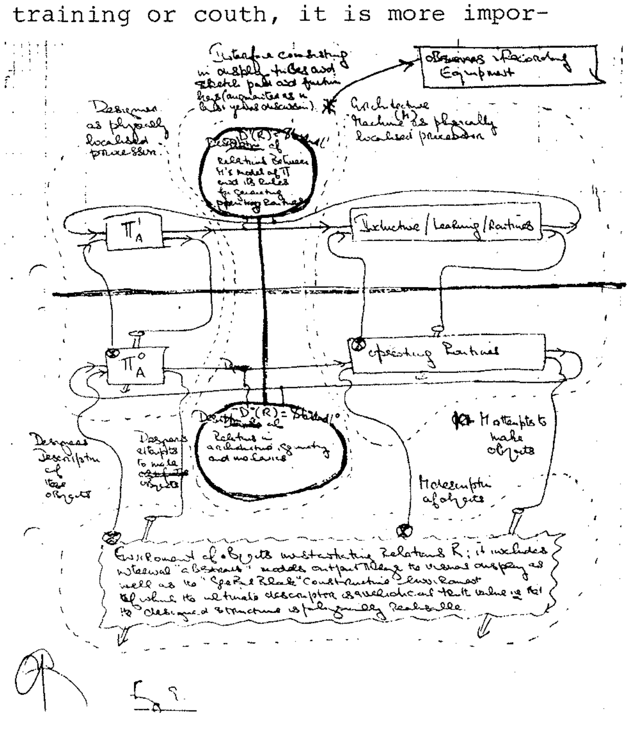
Cognitive Styles and Graphics

Our facial expressions, gestures, way of talking, are all indications of and result from our individual personalities. It is not difficult to extrapolate and to project similar indices, like those of cognitive style, from drawing. In literature we find a curious absence of research in this area, with the exception of clinical psychiatry, notably Machover (19), Bender (20), and Goodnough (21), and with the exception of graphology (22). While the latter, the study of personality in handwriting, is suspect and frequently accused of being metaphysics, it is interesting to note that advanced degrees are offered in graphology at seven different German Universities.

These precedents may be able to be knit together with prudence into a well formed theory of drawing. But, so far, the results are far beyond the basic need for idiosyncratic graphics. In the one case, drawings are used to uncover deep psychological traits (or problems), using the content of the drawing as much as the linework. In the other case, expert interpretations are as much social (characteristics of: leadership, magnanimity, of sense of humor) as cognitive ("good faculty for logical reasoning," "unwilling to go back," "experience by trial and error").

More current and perhaps appropos is the work of Gordon Pask (23). "Styles encompass gross differences like comprehension/operation learning and the global/local orientation, as well as relatively precise characterizations of learning strategy, for example, wholist/serialist and the subcategories redundant/irredundant wholist." This taxonomy of cognitive style is important when, for example, you view computer-aided design as in the domain of computer aided instruction, particularly in the LOGO (24) sense of learning through doing. The anecdotal evidence resides in Pask's own diagrams, violently wholist, as for example in the one at the bottom of this column, taken from his introduction to my own book, Soft Architecture Machines.

Interpretations of cognitive styles can come equally from preferences and implementations of graphical format. I am personally most comfortable with a Swiss graphics of terse structure, bent upon having my display in Helvetica Medium. However, I observe students developing computer programs whose light buttons, for example, are scattered and boxed off like an IRS form. While it is easy to discard this as the lack of graphical training or couth, it is more important to simply recognize that the comfort arises from it being the student's "form." Once again, the user has designed it.



Graphical Conversations

Conversation theory is exceptionally new, a good start is found in Conversation, Cognition and Learning (26) and the previous reference to Pask (23). We are simply not accustomed to holding graphical conversations. For the most part, a conversation is achieved through spoken language. Furthermore, it is augmented by intonations (even available over the telephone), gestures, and facial expressions. Sometimes conversations refer to visual aids, but they are not per se graphical. The closest we can get to a graphical conversation is some kind of blackboard argument between two headstrong designers, each with chalk and eraser in hand, raging over a schematic, which over time passes from being a well delineated proposition to being a smudge (with the protagonists probably covered in chalk).

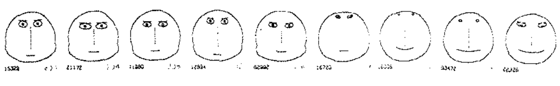
An emerging exception is found in the potentialities of the founding work of Dr. Gordon Thompson (27). His notion, in retort to the Picturephone, is one of shared graphical space, currently and tentatively called "Scribblephone." Though untested in a consumer world (yet), It offers the opportunity for graphical conversation between two remote people, from which we may get some empirical results useful for the occasion when one of the conversants is not a person, but a machine.

Let us assume for the moment that our graphical conversation is not augmented by any other medium. Also, let us limit graphics to pictures, lines, and shapes. What are some of the distinguishing features of that conversation and how can we capitalize upon these differences to enhance the interactiveness?

Graphical conversations are iconic and not symbolic. They are communal, adjacent, or metaphorical (28). This is true equally for an electrical schematic, section of a fuselage, or rendering of a house design. The most important and distinguishing feature of a graphical conversation is that the topic (or referent) is in the same space and time as the conversants. Unlike a verbal discussion on, let us say, politics, where the referents are distant in both space and time, the referent of a graphical conversation (within the above limitation) is immediate. Whether we are dealing with diagrams or projective geometry, abstractions or photographs, we are not conducting symbol manipulations, common to algebra or natural language. I believe that this offers a kernel of rigor for the definition of interactive graphics.

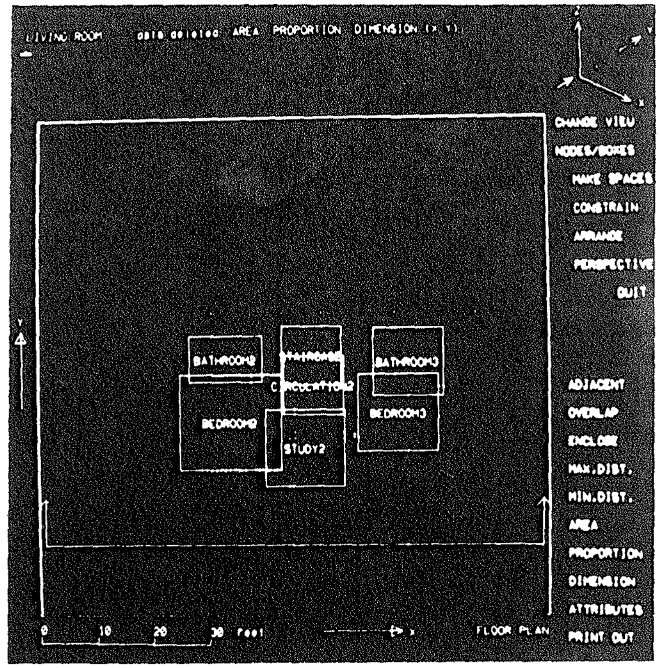
The spatial and temporal immediacy of a

graphical conversation is certainly true for computer-aided design, image processing, and process control (application areas culled from the ACM/SIGGRAPH announcement of this workshop). A candidate exception to be observed is that of data collection, display, and analysis. While worrying about the exceptions to my hypothesis, I remember the work of Chernoff (29) who has displayed multivariate statistical information in k-dimensional space (where k has been as high as 18) by a cartoon of a face whose features correspond to the k-components of a particular data point. While not pursued by Chernoff, the explanation for

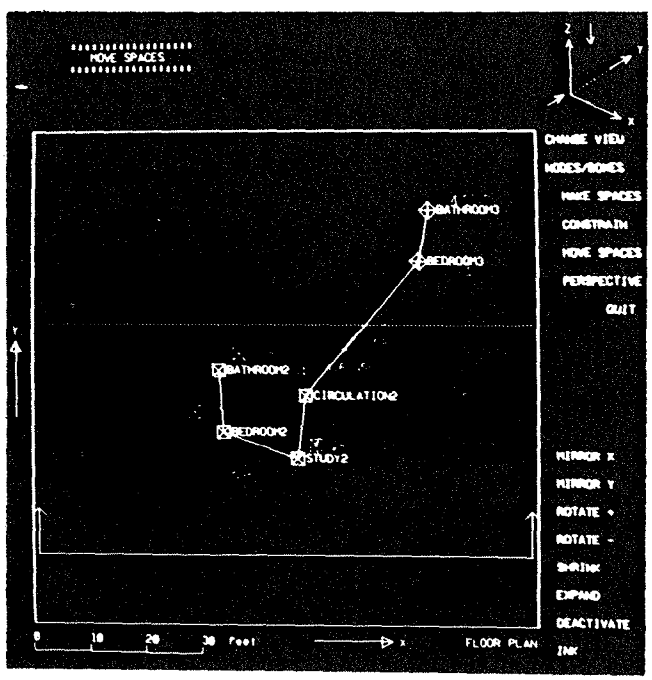


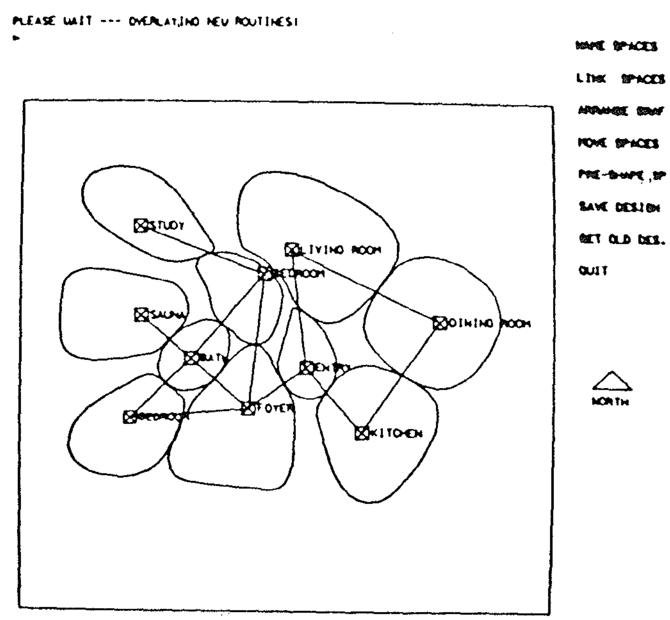
efficient understanding of his data by subjects may be found in the referent being the face, rather than the data which generated it. This would be harder to argue for pie charts, bar graphs and the like. But, ultimately the limitation on the graphical conversation will have to be lifted, alphanumerics allowed, with augmentation of sound and voice. Consequently the propriety of the theory of immediacy is only useful insofar as we have had none.

In looking for examples to illustrate features of or criteria for a graphical interaction (as I was instructed to do), I am immediately stymied by the ubiquitous tit-for-tat nature of the conversation. The generally accepted paradigm for interactive graphics is a process of



taking turns; the user does something, the machine responds, or "the system follows a user action." I offer as an early exception my own very early work (30,31), but more recently the work of Masanori Nagashima (32), built upon the founding efforts of IMAGE (33,34). In his work he maintains a veritable foreground and background, the beginning of a conversation. The computer is manipulating the graphics in parallel with the user. In this case, the machine does local optimization and relaxation of constraints, while the user handles global goals and fiddles with criteria.





A more potentially more relevant example for graphical conversation theory may be found in the present work of Guy Weinzapfel (35), Architecture-by-yourself. While it currently suffers from a serialist limitation, it offers a more idiosyncratic example. For one, the user is working on a problem important and particular to him or her, the outcome for which he or she bears the risk. For another, the referent is a house, for which we can imagine hordes of relevant knowledge or what Minsky (36) would call "frames" (structural, mechanical, cost-estimating), but for which we cannot imagine a know-better (on how you or I ought to live). This means that potentially the conversation is two-way, the beginnings of a dialogue as opposed to what Warren McCulloch would call two monologues.

A final detail in the implementation of Architecture-by-yourself warrants attention in our theme of interactive graphics. Namely, the bubble diagrams. They are computer implementations of a common graphical device used to understand taxonomies, without the surreptitious introduction of shape. In all Architectural applications of which I am aware, the design solution has the signature of Δx and Δy, common to graphics devices and languages, yielding the proverbial rectangle. It would be nice to consider conversational domains that truly avoided the Gestalt of a programming language. Architectural historians frequently tend to matters of conceptual origin, such as physical modelling with sugar cubes versus cardboard versus clay, revealing itself in the built form. I wonder if n-years hence we will be looking back and recognize the Architecture of LISP from that of PL/1.

CONCLUSION

In conclusion I restate my discomfort with the subtitle: "Application Specific User Behavior and Cognition in Interactive Graphics Systems." What it conjures is a set of elaborations like the following:

1. color is inexpensive in raster scan displays
2. mapping applications frequently need color
3. hue-saturation-intensity are separately distinguishable
4. hence thematic mapping should have suchandsuch specification

Not only would the resulting system be disappointing to the color blind user, but would not necessarily be more user-oriented than the previous black & white calligraphic display. The medium is not the message in an interactive system. The message is how I organize it for myself and, more wishfully, how it organizes itself for me.

But then what do we do in computer graphics research? Is there an underlying theory to be found? There is surely a theory of graphical conversation, but developing it will be no small task. In the meanwhile, we should keep in mind the both/and attitude and build specific systems which respect, even in a token fashion, the idiosyncracies of future users. Some of the simple ideas of "user-profiles" in time-sharing or the DWIM (Do What I Mean) Command in Interlisp (37), do yet have graphical counterparts. A simple exception is the common law practice at The Architecture Machine of programming in a deference to right- and left-handedness.

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