# Animation and Continuity: Prerequisites for intuitive Navigation in Virtual Systems

HARTMUT GINNOW-MERKERT

*Kunsthochschule Berlin-Weissensee*

*Keywords: intuitive interaction, design, physical world*

**Abstract**

A user's ability to approach a complex technical system *intuitively* depends on the proper design of the software (and hardware) structures representing its functional repertoire. If we learn to design and present the functionality of a technical product – or system – analog to some of the qualities of the “Real World”, we enable users to rely on their genetically predetermined or acquired behavioral inventory. Thus interfaces need not to be learned, they appear natural at the first glance. Essential design parameters are the principles of continuity and animation. This paper represents and illustrates the author's argument indicated in the title.

## 1. The current problem with user interfaces

You visit a website and click on a link. A new page appears. You navigate in the menu structure of a mobile phone to locate a particular function. Now I want to return to the starting point. But where am I? How do I get back? What do I need to do?

*Heeelp!*

A few steps in the complex functional universe of a contemporary digital product or system leave the user disoriented and lost. Unsurprisingly, only a few primary functions of the product are ever to be used, while an overwhelming proportion of such the digital universe remains obscure, never to be visited again. Worse: while we can lock the door to a scary basement, the undesired elements of a digital universe keep haunting us throughout our interaction with such a device or system. At every step in our interaction do they get in our way, block our view of the target, and add to our frustration.

When talking about Emotional Design, frustration is among the least desirable emotions our products are supposed to evoke. We tend to overlook some of the functional deficits of a product when the functional gain exceeds the emotional pain. Or, when we can afford – or have to – endure a long period of training due to the emotional gain of finally having acquired a valuable skill or insight. Or because we simply have no choice. As a result, we may develop some form of a love-hate relationship or truce, which again is not exactly the most desirable level of user acceptance. The lack of excitement with a product and some bad experiences with getting lost in its information jungle may reduce a user's interaction to just the basic functions. All the many extra functions – the pride of engineering and marketing – get ignored by the user, or worse, become major obstacles in the path to those few functions deemed relevant by the user.

But products exist that are praised for their user experience? Why do users talk so positively about Nokia?

## 2. The Functional Universe of a "real" environment

In any real environment – a landscape, a city – visitors are confronted with a multitude of functions. Stores, buses, roads, billboards, services of all kinds, areas for rest or playgrounds all together constitute the functional universe of a city which again is only a part of a greater functional universe.

In any functional universe users exist in a variety of user modes. Even the same person exists in different modes at different times. The user may be in a – focused – hurry to catch the bus, and minutes later he or she switches to the relaxed "browsing" mode strolling through a shopping mall or exhibit. We may have just arrived in this city, or we've lived there for years. There are dramatic differences in user disposition and modes of use. Real environments exist as a result of a long Darwinist process of mutual optimization and adaptation, and they usually accommodate people in varied modes of use.

There are maps, there are pedestrian sidewalks, there are trams, and there are taxi drivers ("Intelligent Transportation Assistants"). There are people one can ask for directions. A multitude of familiar clues exist that help users in their decision making: A tourist in a foreign city who is looking for a replacement battery for his digital camera will – intuitively – look for details in peoples' clothing, behavior, and appearance that identify them as locals, if only to reduce the disgrace of hitting upon another tourist.

Today's Homo Digitalis is not that different from his ape-like ancestor as we may wish to believe. Look at the behavior of car drivers in dense traffic, or watch TV with its war scenes, crimes, and rampages following natural catastrophes or soccer games, and you will see how easily the lacerable skin of reason, civilization, and laws easily tears under the powerful forces of the neuro-chemical processes that control us at every moment of our lives.

Whether we live in the Savannas of Africa or in a modern urban jungle: the principles of orientation and navigation remain the same. Our behavior follows identical patterns of cognition and decision making that we brought with us as our genetic dowry.

Obviously, our behavior in the "Real World" is intuitive. Nobody needs to tell our environment in which mode we prefer to use it. It is simply there, and we can use it any which way we choose.

In addition to the many ways we can use, travel, and orient in our natural environment, the real world has certain characteristics that every person in the universe irrespective of their cultural, educational, or genetic backgrounds recognize and perceive as "proper". Some of these properties shall be investigated in the subsequent chapters.

# 3. "Trivial" properties of a real-world environment

The universe in which we live is a three-dimensional one. Scientists even talk about n-dimensional universes, and we may choose to treat time as a fourth dimension with limited access. However, all of our navigation and orientation takes place on the surface of our planet, in a two-dimensional space. Our movement in the third dimension (hopping, jumping, climbing) is usually connected with considerable effort, and only the able-bodied would engage in such activity for an extended period of time. All the others employ tools and aids of which plenty were invented long before and after Leonardo da Vinci began to reflect upon flying machines.

Fact is: Even if we move about the floors and parking decks of an apparently three-dimensional multi-story edifice, we navigate along stacked surfaces, and the thinking of most architects is limited to that of stacked surfaces, as if this were all that humans would ever have in a three-dimensional world.

But humans invented tools that truly elevate us into the third dimension. What about airplanes and space ships?

If you fly airplanes or space ships for a living you will have undergone hundreds if not thousands of hours of special training, just so you are able to find your way around the third dimension and back. Travel in the third dimension comes with a lot of extra cognitive work, and even if you are able to fly a small airplane or helicopter you will try very hard to limit your freedom of rotational movement to that about the vertical axis only. Why am I going through these seemingly trivial observations? Simply because we have to acknowledge that the human cognitive apparatus is well equipped for travel and navigation along a two-dimensional plane, but much less so for travel everywhere else.

Children's play is not play at all. When children (or adults) play, they follow a genetically programmed urge to explore the properties of the physical world and the objects it comes with. A toddler playing with building bricks experiences a law of nature that will enable him later to avoid potentially painful experiences with objects that get into or come flying his way. He will forever have acquired the insight that two solid objects cannot occupy the same space in the physical world. If one nevertheless tries, it will hurt. If we successfully manage to put object A into a matching hollow B, we will be rewarded with a dose of an endogenous drug. A diminishing level of endogenous drugs produced by the same action explains drug addiction on one hand. On the other hand it explains why we sense a continued urge to explore the physical world forever, and thus seek new endogenous drug production engaging in seemingly vain activities such as bungee jumping, running, and mountain climbing – to name a few. Biochemical mechanisms drive most of our behavior. Neuroscience is just beginning to understand the powerful biochemical reward mechanisms that control our every behavior and that are at the root of every play or game, even well into our adulthood. Shouldn't designers begin to explore the power of endogenous drug production, so our interfaces could be explored using the same powers that drive our everyday behavior in the real world?

If two solid objects cannot occupy the same place in the universe known to humans, we can follow that every solid object in the universe (as we know it) must have its own unique space. This rule is so basic to our understanding of the physical world that we do not even think about it on a daily base. Yet, it controls our behavior to such a degree that whenever we walk through a door we look for clues that enable us to open the door in the proper direction. In the absence of such clues – e.g. when "clever" designers or architects made the door blade flush with the frame – we have to guess, and our guess will be 50% wrong. *Push* or *Pull* signs represent a band-aid approach to design; they are mere "crutches" causing multiple micro incidents of frustration throughout the day. Why? Because they need to be read and interpreted and thus require more attention and time for processing. Frustration is one of the least desirable forms of emotion that we the designers could generate. Shouldn't we rather strive to produce positive emotions that guide the user towards the right action without knowing?

Another seemingly trivial property of the real world is rooted in our observation of the movement of objects. If a child moves an object from one location to another, this transition occurs within the scope of our cognitive abilities. As every object occupies its own unique location in the real world, movement allows us to keep track of the location of any object, and we will always associate an object with its location.

We also observe that all the locations of objects in the physical world are connected. We can travel from one place to another everywhere in the known universe. We may employ different navigation and transportation strategies. In the long run, if we have traveled about a portion of the universe, all the objects and places we have seen are placed in a mental map whose level of detail and reliability increase with use and which enables us to find your way back and around in a city, on top of a desk, or in a room. Take the location property of objects away and place a number of them in the same location, and you will have difficulties finding a particular object. Have you ever seen your friend rummage in her handbag for her cell phone?

These observations appear trivial, because they are so basic to our everyday experience that we do not even think about them. Acting without conscious thinking is what we call intuitive, and intuitive interaction is what we strive for in the design of complex objects (e.g. mobile phones) or systems (e.g. websites). It is just the trivial aspects of life that are hidden from our view, just as we cannot see the wood for the trees. Making the trees visible to the designer is the purpose of the consideration presented here. Trivial design thus becomes desirable.

The transition[1] of an object from one place to another is observable. Any object in our known universe has a singular (discrete) location. All locations in the universe are somehow connected. It is possible to move from any location in the universe to any other location. Oftentimes it will be necessary to employ different navigation

[1] Transition: The (visual) observation of the change of an object from one state (e.g. location) to another. The author postulates that all transitions should be transparent to the user ("observable").

strategies, or even to combine various strategies. So it is not unusual for us to drive our car to the airport, go by plane to a distant city and ask a local for directions to an office building where we will take an elevator to the 10th floor. After doing so for a number of times we will be able to remember the locations of a number of objects, and to recall them from our mental map when the next visit is called for.

Apparently humans – as well as most autonomous living beings – are capable of composing a mental map of their environment, as long as they are given a chance to identify the unique location of a target object and watch their progress toward it. Consequently, it is not only possible for us to find a location in a distant town or country. Just as easily do we find our fountain pen on a busy desk top, and a car driver even manages to compose a mental map of the traffic situation around her from a number of separate visual and auditory clues. It is a marvelous feat of the (human) brain that we are able to trace a path across a busy sidewalk without bumping into other people and objects. Our brain accomplishes this and other difficult tasks in "background mode" while we simultaneously read store signs, listen to music, and maintain a conversation with a companion!

These observations allow us to arrive at two principles that appear to characterize our intuitive interaction with the physical universe:

## 3.1 The locations of all objects exist in a continuous universe (The Principle of Continuity)

Any location (e.g. a restaurant) in our physical environment can be reached from any other location (e.g. our home). Locations can be in distant towns or countries, or on the moon. Transportation means may vary. One may combine different means of transportation. The fact that some locations are too far to reach or that transportation means have yet to be invented does not violate the principle. Continuity is never disrupted. Time warps and parallel universes exist only in fantasy movies (or physics labs). *All places are connected.*

## 3.2 The transition of objects from one location to another can be observed

Whenever I travel from one location to another I can watch the objects around me as they change their locations relative to mine. My own movements as well as those of objects around me occur with a motion characteristic that is within my own cognitive range of visual perception. An object that moves too fast or too slow cannot be observed, so information about its transition is not available. Our observation of an object's speed and direction enables us to predict its most likely future position. This ability of the (human) brain evolved out of a mere need for survival: its perfection made the difference between eating and being eaten.

Humans acquire this ability early on. While some adults talk about child's play as an idle pastime, playing is serious business for children. Even those grown-ups that keep their curiosity about the world until late engaging in game playing do not do this "just for fun". Children and grown-ups play, because their biochemical system rewards them with an arsenal of drugs made inside their bodies, the drugs acting upon us like a hard-wired program that makes us learn to become better adapted to the conditions of the physical world. A mother or grandfather playing with a child teach him or her about the powers – and pleasures – of endogenous drugs.

Every ball game has a purpose. So does the game of hide-and-seek, so do car races, boxing, skiing, hunting – every such activity that humans seem to be doing for fun serve the purpose of developing our ability to predict the future location of an object, or to perfect other skills that strengthen our ability to survive in the physical world. What is fun? Fun is a biochemical product that we were equipped with in order to make us do things without which evolution simply wouldn't happen.

Not only do we find emotional satisfaction in the successful launch of a soccer ball in the direction of the enemy's goal. We even *pay* for being given a chance to watch others try! And the emotional reward couldn't be more genuine – just watch the crowds attending any soccer or baseball game!

Motion outside the cognitive range of humans is also of interest: Every magician and every soccer (tennis, etc.) player will attempt to place the movement of an object beyond our ability to watch their transition by moving them too fast, or by diverting our attention for a fraction of a second.

Interestingly, humans have had a curiosity about events that happen outside our cognitive range. Our fascination with a magician's ability to make things go away and reappear from nowhere seems to answer to a secret desire in all of us: to challenge the universal validity of the principles of continuity and animation[2].

In certain situations our ability to observe and interpret transitions gets in the way of a stakeholder's intentions. Consequently, a kidnapper's victim is blindfolded, shoved in the trunk of a vehicle, and driven around the block a number of times. The relevance of our sense of location becomes manifest when the victim still deduces his hiding place from the duration of the trip, the surface conditions of the road, certain movements, as well as sounds and smells. As children we boost our ability to cope with such situations in playful ways: playing hide-and-seek invites us to listen to our senses other than visual, and what a kick (=biochemical reward) we get when we succeed!

In the physical world, humans and objects move in accordance with the laws of nature. Any object is characterized by its inertia, and forces are always finite, so all motion will follow a non-linear trajectory. By watching a physical object accelerate and decelerate, we gain valuable information about its bulk as well as the forces propelling it. This data enters our calculation of its likely future position and thus represents valuable input that humans rely on in their daily lives.

Furthermore, the direction of motion is relevant. Handing an object to another person never follows a straight line. A human observer will interpret the quality of any motion, in order to make the proper decision about one's next action.

Motion carries a vast number of meanings. Motion is aggressive, sick, weak, powerful, natural, or not; never will we leave motion without interpretation. Designers will have to control and define any motion event in the objects or systems they create, and they will need to do so in careful reflection of the human ability to read the meaning.

---

[2] Animation: From the position of the observer there is no difference between the observer moving past an object, or an object moving past the observer. In both cases the memory of the object is stored in the cognitive map of the environment. Everything would be easy if it wasn't for the fact that our environment tends to be bigger than what we can see at once. The instruments of location memory and cognitive maps have evolved for us to keep an overview in large environments.

# 4. About the violation of the principles of continuity and animation in current interfaces

As mentioned earlier, even the manufacturers of upscale automobiles expect their customers to accept less-than-perfect interface solutions. It is no natural law that we must equip our products with “buttons”, ”displays”, or ”menus”. Buttons, displays, and menus are unreflecting choices about a product's sensory equipment defined by technicians who spend too much time staring at their PC's.

Standard wisdom about hierarchical interface structures of *so* many levels with *so* many submenus being optimal for the user is nonsensical. Humans are known to adapt to almost anything, even to hunger, war, and cold climates. But there never was a single moment in those x-million years of human evolution when we had to punch the belly button of our vis-à-vis before we could talk to him!

When a click on a button leads to an instant exchange of display content – as it is often the case in web design and digital products – we are witnessing a violation of continuity and animation. Objects – such as screen content – that disappear in the fraction of a second neither possess a location, nor can we derive their likely position in the absence of observable directional motion clues. Even in case of the most optimistic assumption – that the old object might be covered by the new – we receive no hints that would confirm this assumption. Neither could we observe its transition, nor could we see even a touch of it peeking from underneath. And where are all the other objects?

Maybe in the design phase someone had envisioned a continuous underlying structure that even existed as a graphical map of the product's functional universe. However, in its implementation no clues remain as to where in this structure everything is. And it gets worse.

While we can roughly superimpose the map of a city on its aerial picture, the “map” of the functional universe inside a digital product has no visual relationship with its secondary representation, the user manual. Indeed, user manuals represent the information about any product in such a worthless and unsightly manner that users habitually tend to ignore them. Future “instruction manuals” hopefully will evolve to become meaningful tools in our exploration of a foreign universe similar to the city maps and tourist guides that we are familiar with. Imagine a tourist guide presented in the form and layout of a typical user manual!

Kidnapping or hide-and-seek cannot represent meaningful paradigms for the design of user interfaces. Nevertheless, kidnapping interfaces are still the rule today.

# 5. Demands of future Interface Designers – A Method

Before we should even think of designing the interface of a digital product or website, designers must first develop a meaningful conceptual model[3] of the functional universe inside.

[3] Conceptual model: A mechanical principle of operation that the target user is assumed to understand. The design of a product interface simulates this principle in software and hardware, whereby the level of abstraction can vary. Ideally, the conceptual model is realistic enough to be understood by a user,

Before we do so we have to investigate what kind of users will be the recipients of our work. Are they lay people or experts? What, if any, mechanical background or other experience can they draw from? Should the use mode resemble a leisurely stroll across a shopping lane, or are we in a hurry to reach a certain destination as quickly and efficiently as possible? Do users graduate from layperson to expert over time? Do various use modes occur in the same system? If so, our current “one-size-fits-all” approach to interface design is obsolete! In this case we have to design for variable use modes and expert levels. Interfaces have to recognize a user's particular context of use, and they should adjust automatically. They have to adjust to different learning types and aesthetic preferences. While anybody can choose her new car from a variety of convenience packages, colors, and trims, the interfaces inside come in one, usually dull, version only.

One has to carefully reflect on the “gate” through which a user steps into our virtual world the first time. Subsequent visits may offer faster access. We will need to reflect how the user is guided to the other locations in our universe.

If we want a user's access to the virtual universe to be intuitive, we have to assign a singular location to each of its functions inside a comprehensible functional universe, and we have to make the transition from one location to another observable.

Past arguments against animation in interface design pointed out that graphic processors were “too expensive” if they were to support complex, and smooth, animation. Nowadays, the opposite is true. The loss of emotional value and user happiness is way too expensive for any company to ignore. Saving a dollar here and a penny there is saving in the wrong place. While there is a lot of justified criticism to be mentioned with respect to the iPod, even the first-generation iPod came with a healthy dose of animation in its user interface. However, it is just as detrimental to the cause to use graphic processor power for meaningless “flashy” animation as a mere decorative element. Such abuse of processor power only diverts the user's attention from the meaningful aspects of an interface; it angers and frustrates and contributes to the notion of “cheap”.

Never must an animation happen so fast that it could not be observed. And it never must happen so slowly that a user gets bored or impatient. There is a happy medium somewhere in the range of 0.2 – 0.4 seconds, and with rising user experience this could be brought down close to the 0.1 second bottom limit of visual perception. Smart interpretation and user detection methods are available today, and there is no valid excuse to make users stare at a Windows-style screen in any product touched by a designer.

From the conceptual model we derive the “means of transportation” (hardware interface) to navigate our virtual universe. While we have to respect standards such as the mouse or keyboard in computers, there are many opportunities to reflect upon the usefulness of the typical button-and-display interface design approach. Nowadays, inexpensive sensors exist or are becoming available that can read gestures or eye movement, that are able to read a user's facial expression or understand voice commands. Artificial “noses” sniff the scent molecules emitted by

---

but abstract enough to allow for a user's own discovery, thus generating a feeling of pride, as well as other positive, supporting emotions. A successful cognitive model will result in an identical mental model in the user's mind. This is where design meets usability.

a user thus becoming able to detect stress, anger, the user's identity, or a medical problem. Sound tracking enables systems to read assault situations in public transportation; face tracking is used to interpret a shopper's emotional state. It is the industrial designer's responsibility to know and explore any technology that might enhance a user's interaction with complex artifacts.

When we follow the discussion of the hottest new mobile flip phone or watch the happy face of the owner of a Zippo lighter, or when we observe (hopefully only on TV) the expert unfolding of a butterfly knife, we realize that the tactile, acoustic, and dynamic product qualities are linked to emotion. Why then should we knowingly refrain from designing e-motion into the digital worlds that reside in our products? Why isn't there the same urge in designers to make a user's interaction with a digital product universe emotional and pleasurable? Emotion and pleasure are the driving forces in human behavior, purchasing decisions are based on emotional grounds. The rational aspects of human behavior looses out if in conflict with our emotional hard wiring. And this will be the case for at least another few millions of years.

Once we define the conceptual model of the functional universe inside a product, – and only after the appropriate hardware interface has been defined – can we begin to design the exterior of the product. The digital world inside may not present itself through just one display. Maybe there are distributed displays, maybe there is no display at all. Maybe the product communicates via “product body language” and product gestures. Maybe there are no buttons, because a built-in camera or other sensory equipment “reads” the user's desires. The existence of displays and buttons has such an impact on a product's exterior that it is simply impossible to design without first having taken care of these basic decisions. While in the “old days” technical constraints often forced the designer to bow to a long list of engineering requirements, engineering now is able to cater to almost any whim of the designer. Our constraints now derive from what a human brain is able – and willing – to process. Designers can no longer subject their creativity to the now meaningless engineering requirements of the past. However, while claiming a more relevant role in the product development team, designers are burdened with the responsibility to base their decisions on solid data and scientific fact. No design education should ignore the relevance of cognitive and evolutionary psychology, (cultural) anthropology, and even neuroscience, only to name a few of the partner disciplines without which to execute our profession would be frivolous.

So this is the five-step method for our design of complex digital products:

**Step 1:** Determine the type of user(s) that will be exposed to the product, as well as their use mode(s)

**Step 2:** Determine the (emotional) reward mechanisms that should be used to drive the user's exploration of the digital universe inside the product

**Step 3:** Determine the most suitable conceptual model that enables the user to understand the digital universe inside the product

**Step 4:** Determine the proper hardware means for the user to navigate the product's digital universe

**Step 5:** Design the product's exterior

We should also say goodbye to the old concepts of *controlling* a product (even worse are the German terms “Fernbedienung[4]”, “ein Produkt bedienen[5]”, ”Bedienanleitung[6]”, as they imply that humans serve the object!). While, of course, products are tools or servants and thus derive their existence from their servant role, they have become smarter and more powerful, and the way we communicate is about to change. Human interaction with products will evolve to become a form of dialog in which body postures, gestures, facial expression and voice are only a few of the interaction components.

Products of today's high levels of complexity will exhibit a more complex behavior than the tools of the past. They will adjust to different users and situations, and their behavior will not always be as predictable and transparent as, say, that of a vending machine. The next generation of complex digital products will have “personalities” that are communicated to the user by their appearance and behavior. Designers will increasingly find themselves in the business of designing a product's personality and body language. Choosing the right manufacturing process was easy then; designing a consistent product personality requires a deep understanding of the human psyche and a high level of analytical thinking. Design education will have to change dramatically. And design research will finally become a mandatory academic requirement. Design will finally leave the lone-genius era, just like the medical field left behind the quack doctors of the Middle Ages.

# 6. Three examples

The following examples may serve to illustrate the principles of continuity and animation as outlined in this paper. While still pictures cannot give the same impression as the interactive simulations[7] from which these examples were taken, the written explanations hopefully illustrate the concepts behind them.

## 6.1 Example 1: Conceptual model (left) and display (right) of a truck driver's assistance system

*Design: Ashley Moran (1998)*

Four functional sectors representing the functional areas of the truck driver's PDA “glide” into the center position from their standby locations in the four corners of the display. The four quadrants correspond to a four-button hardware interface in the driver's armrest. Each of the four functional sectors has its unique location; animation is swift but perceivable.

[4] “Remote control”
[5] “Control a product”
[6] “Operating manual”
[7] Simulation: Computer-based modeling, or prototyping, of an interface. In design education we tend to use non-proprietary versatile software (e.g. Adobe Flash or Director) for interface prototyping, because of the fact that these give complete and unlimited control of the design solutions to the designer. Dedicated interface software often interferes with creativity and innovative thinking.


*Figure 1: Conceptual model (left) and the resulting display content (right) in their stand-by state. The four-segment panel is in its center position.*

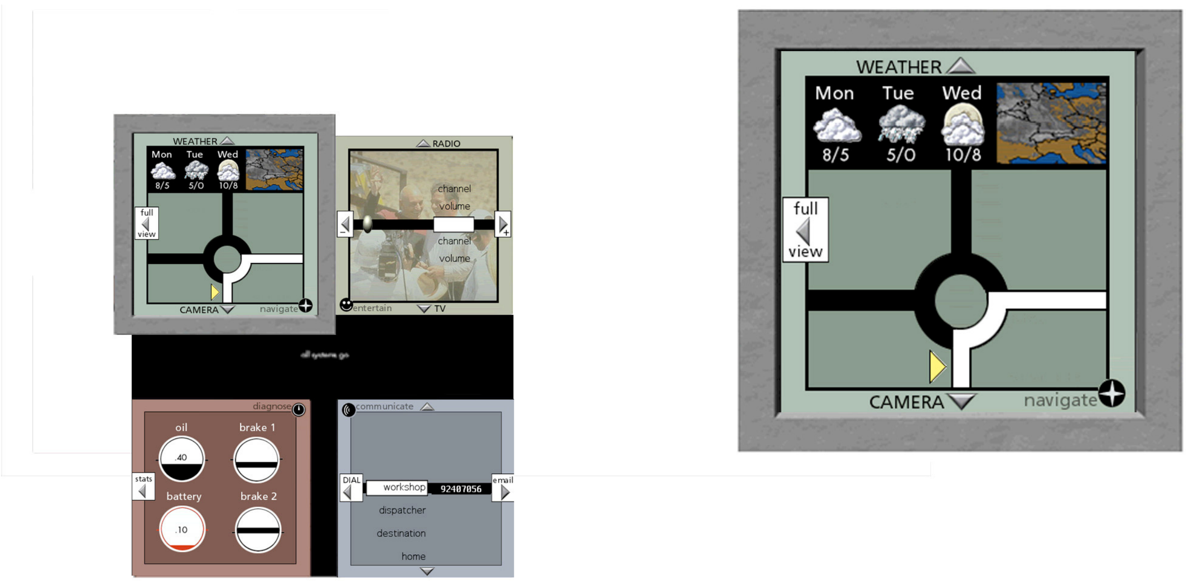


*Figure 2: Conceptual model (left) and the resulting display content (right) when the "Navigation" function is in use. The four-segment panel has moved to the lower right underneath the (fixed) display frame. The use of animation makes the transition transparent*

## 6.2 Example 2: Conceptual model (left) of a washing machine interface and its implementation.

*Design: Hartmut Ginnow-Merkert*

Menu items are arranged as a liner list that can be scrolled up or down by means of a "rack and pinion" mechanism that a lay person with little technical background would easily understand. The location of the rotary knob on the horizontal center axis of the display is crucial for the user's understanding of the conceptual model.


*Figure 3: The picture shows the conceptual model (left) and its implementation in a computer simulation (right). Animation is crucial for a user's understanding of the conceptual model.*

### 6.3 Example 3: Conceptual model (left) of a radio dial and its implementation via a flexible OLED.

*Design: Hartmut Ginnow-Merkert*

A list of radio stations is arranged as a linear list and pulled across a cylinder. The display implementation resembles the visible portion of the cylindrical portion of the "paper sheet".

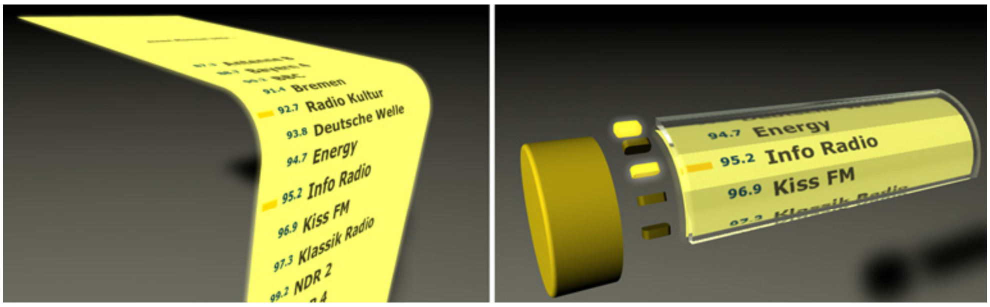


*Figure 4: The picture shows the conceptual model (left) and its implementation in a computer simulation (right). Animation is crucial for a user's understanding of the conceptual model.*

## 7. Outlook

Beyond continuity and animation, other concepts are waiting for their discovery and translation to the virtual environments that are the subject of the thoughts presented here.

There is the concept of *redundancy* – objects are defined and distinguished by a multitude of qualities such as size, form, colors, materials, location, sounds, smells, and others. We find any object easily – and often without looking – as long as we placed it on the desk ourselves. But have somebody benevolent "clean up" our desk, and it will take much longer to find a specific item.

Take any one of these redundancy factors away (e.g. location), and things will be much harder to find. Object qualities are interconnected by association. The fact that smell is a powerful means of memory may make a difference in the design of future interfaces. The fact that our brain is capable of recognizing minute differences in the dimension of the human vocal apparatus may be used in the digital products of the near future, in order to detect different users and their moods.

Another real-world concept is that of *pattern recognition*. Isn't it amazing that we can recognize a familiar person from a distance in a big crowd? Even when she's not looking our way we take clues about her skin tone, clothing, body size, and stride. Try to write a computer program that accomplished the same feat, and you will realize the incredible power of the pattern recognition processor in the (human) brains. So why not design interfaces that employ this ability, instead of ignoring it by neatly arranging identical-looking items along minimalist gridline patterns that were possibly in order in the era of print media but no longer serve their purpose in a complex digital environment.

These and other real-world concepts will be the subject of future investigation.