show is usually the same, so that a pattern recognition system **2505** of the video frame could indicate the presence of that newscaster. In addition, the satellite photographs, weather radar, computer generated weather forecast screens, etc. are often similar for each broadcast. Finally, news segments, such as "weather" often appear at the same relative time in the broadcast. Using this information, the interface could begin recording at a beginning of a news segment, such as "weather", stop recording during commercials, and continue recording after return from break, on all selected channels. It is noted that the system of the present invention is intelligent, and may therefore "learn" either explicitly, or through training. Therefore, if the system made an error during the process, the user would define the error to the system, e.g., a substitute newscaster or rearrangement of news segments, so that the system has a reduced likelihood of making the same error again. Thus, while such a system is inherently complex, it poses significant advantages for an user. Further, while the system is complicated, the interface provides simplicity, with inductive reasoning and deductive reasoning.

It is noted that various algorithms and formulae for pattern recognition, correlation, data compression, transforms, etc., are known to those skilled in the art, and are available in compendiums, such as Netravali, Arun N., and Haskell, Barry G., "Digital Pictures Representation and Compression", Plenum Press, New York (1988); Baxes, Gregory A., "Digital Signal Processing, A Practical Primer", Prentice-Hall, Englewood Cliffs, N.J. (1984); Gonzalez, Rafael C., "Digital Image Processing", Addison-Wesley, Reading, Mass. (1987), and, of a more general nature, Press, William H. et al, "Numerical Recipes in C The Art of Scientific Computing", Cambridge University Press, 1988, which are incorporated herein by reference.

A further example of the use of the advanced intelligent features of the present invention would be the use of the system to record, e.g., "live" musical performances. These occur on many "talk" shows, such as "Tonight Show with Johnny Carson" (NBC, 11:30 p.m. to 12:30 p.m., weeknights), "Saturday Night Live" (NBC 11:30 p.m. to 1:00 a.m. Saturday–Sunday), and other shows such as the "Grammy Awards". The interface, if requested by the user to record such performances, would seek to determine their occurrence by, e.g.: analyzing a broadcast schedule; interacting with the on-line database **2411**; and by reference to the local database **2413**. When the interface determines with high probability that a broadcast will occur, it then monitors the channel(s) at the indicated time(s), through the plurality of tuners **2502**. In the case of for example, pay-per-view systems, which incorporate encrypted signals, an encryption/decryption unit **2509** is provided for decrypting the transmitted signal for analysis and viewing. This unit also allows encryption of material in other modes of operation. During the monitoring, the interface system acquires the audio and video information being broadcast, through the signal receiver **2408**, and correlates this information with a known profile of a "live musical performance", in the preference and event correlator **2412**. This must be distinguished from music as a part of, e.g., a soundtrack, as well as "musicals" which are part of movies and recorded operas, if these are not desired. Further, music videos may also be undesirable. When the correlation is high between the broadcast and a reference profile of a "live musical performance", the system selects the broadcast for retention. In this case, the information in the intermediate storage **2503** is transferred to the plant **2507**, which includes a permanent storage device **2508**. The intermediate storage **2503** medium is used to record a "buffer" segment, so that none of the broadcast is lost while the system determines the nature of the broadcast. This, of course, allows an extended period for the determination of the type of broadcast, so that, while real-time recognition is preferred, it is not absolutely necessary in order to gain the advantages of the present invention.

Thus, while it is preferable to make a determination in real time, it is possible to make an ex post facto determination of the nature of the broadcast program. By using an available delay, e.g., about 5 to about 300 seconds, or longer, the reliability of the determination can be greatly increased as compared to an analysis of a few frames of video data, e.g., about 15 to about 300 mS. As stated above, the determination storage need not be uncompressed nor lossless, so long as features necessary to determine the character of the broadcast are present. However, it is preferred that for broadcast recording, the storage be as accurate as possible, so that if a compression algorithm is implemented, it be as lossless as possible. The MPEG II standard would be applicable in this situation. In a preferred situation, approximately 5 minutes of broadcast material is analyzed in order to make a determination of the content. This material is stored in two media. First, it is stored by normal systems on video tape. Second, it is received in parallel by the computer control, where the data is subject to a number of recognition and characterization processes. These are performed in parallel and in series, to form an extracted feature storage matrix.

A preferred method incorporates one or more digital signal processor based coprocessor elements, which may be present on, e.g., Nubus cards in the Macintosh ci or other computer type. These elements may be based on C-Cube CL550 (JPEG compression), American Telephone and Telegraph Co. (AT&T) DSP32C, AT&T DSP3210, AMD 29000 series, Motorola DSP 96000ADS, Texas Instruments TMS 32050, etc, or a combination of types. A typical board containing a DSP is the MacDSP3210 by Spectral Innovations Inc., containing an AT&T digital signal processor and an MC68020 Complex Instruction Set Computer (CISC) processor, and uses Apple Real-time Operating System Executive (A/ROSE) and Visible Cache Operating System (VCOS). It is preferred that the processors employed be optimized for image processing, because of their higher throughput in the present applications, to process the video signals, and more general purpose signal processors to analyze the audio signals, because of the greater availability of software to analyze audio signals on these processors, as well as their particular strengths in this area. An array processor which may be interfaced with a Macintosh is the Superserver-C available from Pacific Parallel Research Inc., incorporating parallel Inmos Transputers. Such an array processor may be suitable for parallel analysis of the image segment and classification of its attributes. Pattern recognition, especially after preprocessing of the data signal by digital signal processors and image compression engines, may also be assisted by logical inference engines, such as FUTURE (Fuzzy Information Processing Turbo Engine) by The Laboratory for International Fuzzy Engineering (LIFE), which incorporates multiple Fuzzy Set Processors (FSP), which are single-instruction, multiple data path (SIMD) processors. Using a fuzzy logic paradigm, the processing system may provide a best fit output to a set of inputs more efficiently than standard computational techniques, and since the presently desired result requires a "best guess", rather than a very accurate determination, the present interface is an appropriate application of this technology. As noted above, these processors may also serve other functions such as voice recognition for the interface, or extracting text from video transmissions and interpreting it. It is also noted that, while these coprocessing engines are now costly, the present emergence of high levels of integration of functionality on semiconductor chips, as well as the development of optical computers will dramatically reduce the cost of implementing this aspect of the present invention; however, the present state of the art allows the basic functions to be performed.

It is noted that various methods are available for determining a relatedness of two sets of data, such as an image or a representation of an image. These include the determination of Hausdorff distance, fuzzy correlation, arithmetic correlation, mean square error, neural network "energy" minimization, covariance, cross correlation, and other known methods, which may be applied to the raw data or after a transformation process, such as an Affine transformation, a Fourier transformation, a warping transformation, and a color map transformation. Further, it is emphasized that, in image or pattern recognition systems, there is no need that the entire image be correlated or even analyzed, nor that any correlation be based on the entirety of that image analyzed. Further, it is advantageous to allow redundancy, so that it is not necessary to have unique designations for the various aspects of the data to be recognized, nor the patterns to be identified as matching the uncharacterized input data.

The MSHELL from Applied Coherent Technology is a software system that runs on a Mercury MC3200 array processor, in conjunction with a Data Translation DT2861 or DT2862. The NDS1000 Development System from Nestor, Inc., provides image recognition software which runs on a PC compatible computer and a Data Translation DT2878. The above mentioned processing hardware and software, as known, is incorporated herein.

The C-Cube CL550 is fully disclosed in "C-Cube CL550 JPEG Image Compression Processor", Preliminary Data Book, August 1991, and addendum dated Nov. 20, 1991, incorporated herein by reference, and products incorporating the CL550 include the JPEG Video Development Kit (ISA bus card with Chips and Technologies PC video 82C9001A Video Window Controller), and the C-Cube CL550 Development Board/PC for Industry Standard Adapter (ISA, the IBM-PC bus standard) Bus (CL550, for use with Truevision TARGA-16 or ATVista cards) or for NuBus (Macintosh). The so-called C-Cube "CL950" (unofficially announced) is a MPEG decoder device. Such a device as the CL950 may be particularly useful for use in the present VCR for reproducing compressed program material, which may be compressed by the present apparatus, or may be used for decompressing pre-compressed program material.

It is noted that all functions of a VCR would also be simplified by the use of such powerful processors, and thus it is not only these advanced functions which are facilitated by the processors. It is also noted that these image recognition functions need not necessarily all be executed local to the user, and may in fact be centralized. This would be advantageous for two reasons: first, the user need not have an entire system of hardware in the VCR, and second, many of the operations which must be performed are common to a number of users, so that there is a net efficiency to be gained.

EXAMPLE 3

The interface of the present invention incorporates an intelligent user interface level determination. This function analyzes the quality of the user input, rather than its content. Thus, this differs from the normal interface user level determination which requires an explicit entry of the desired user level, which is maintained throughout the interface until explicitly changed. The present interface may incorporate the "smart screen" feature discussed above, which may, through its analysis of the past user interaction with the interface predict the predicted user input function. Thus, the predictive aspects of Example 1 may be considered a species of the intelligent user level interface of Example 2. However, the following better serves to define this aspect of the invention.

The input device, in addition to defining a desired command, also provides certain information about the user which has heretofore been generally ignored or intentionally removed. With respect to a two-dimensional input device, such as a mouse, trackball, joystick, etc., this information includes a velocity component, an efficiency of input, an accuracy of input, an interruption of input, and a high frequency component of input. This system is shown schematically in FIG. **21**, which has a speed detector **2104**, a path optimization detector **2105**, a selection quality detector **2106**, a current programming status **2108**, an error counter **2109**, a cancel counter **2110**, a high frequency signal component detector **2112**, an accuracy detector **2113** and a physio-dynamic optimization detector **2114**. In addition, FIG. **21** also shows that the interface also uses a past user history **2107**, an explicit user level choice **2111** and an explicit help request **2115**.

This list is not exclusive, and is somewhat dependent on the characteristics of the specific input device. For a mouse, trackball, or other like device, the velocity or speed component refers to the speed of movement of the sensing element, i.e. the rotating ball. This may also be direction sensitive, i.e., velocity vector. It is inferred that, all other things being equal, the higher the velocity, the higher the likelihood that the user "knows" what he is doing.

The efficiency of input refers to two aspects of the user interface. First, it refers to the selection of that choice which most simply leads to the selection of the desired selection. For example, if "noon" is an available choice along with direct entry of numbers, then the selection of "noon" instead of "12:00 p.m." would be more efficient. The second aspect of efficiency has to do with the path taken by the user in moving a menu selection cursor from a current position to a desired position. For example, a random curve or swiggle between locations is less efficient than a straight line. This effect is limited, and must be analyzed in conjunction with the amount of time it takes to move from one location of a cursor on the screen to another; if the speed of movement is very rapid, i.e. less than about 400 mS for a full screen length movement, then an inefficiency in path is likely due to the momentum of the mouse and hand, momentum of the rolling ball, or a physiological arc of a joint. This aspect is detected by the physio-dynamic optimization detector **2114**. Thus, only if the movement is slow, deliberate, and inefficient, should this factor weigh heavily. It is noted that arcs of movement, as well as uncritical damping of movement around the terminal position may be more efficient, and a straight path actually inefficient, so that the interface may act accordingly where indicated. Thus, an "efficient" movement would indicate an user who may work at a high level, and conversely, an inefficient movement would indicate a user who should be presented with simpler choices.

Likewise, if a movement is abrupt or interrupted, yet follows an efficient path, this would indicate a probable need for a lower user interface level. This would be detected in a number of elements shown in FIG. **21**, the speed detector **2104**, a high frequency signal component detector **2112**, an accuracy detector **2113** and a physio-dynamic optimization detector **2114**. In addition, FIG. **21** also shows the use of a past user history **2107**, an explicit user level choice **2111** and an explicit help request **2115**.

While the interface may incorporate screen buttons which are smart, i.e. those which intelligently resolve ambiguous end locations, the accuracy of the endpoint is another factor in determining the probable level of the user. Thus, for example, if a 14" color monitor screen is used, having a resolution of 640 by 480 pixels, an accurate endpoint location would be within a central area of a screen button of size about 0.3" by about 1.0", would be an area of about 0.25" by about 0.75". A cursor location outside this location, but inside the screen button confines would indicate an average user, while a cursor location outside the screen button may be inferred to indicate the button, with an indication that the user is less experienced in using the pointing device.

Finally, in addition to the efficiency of the path of the cursor pointing device, a high frequency component may be extracted from the pointer signal by the high frequency signal component detector **2112**, which would indicate a physical infirmity of the user (tremor), a distraction in using the interface, indecision in use, or environmental disturbance such as vibration. In this case, the presence of a large amount of high frequency signal indicates that, at least, the cursor movement is likely to be inaccurate, and possibly that the user desires a lower user level. While this is ambiguous based on the high frequency signal content alone, in conjunction with the other indicia, it may be interpreted. If, for example, the jitter is due to environmental vibrations, and the user is actually a high level user, then the response of the user level adjust system would be to provide a screen display with a lowered required accuracy of cursor placement, without necessarily qualitatively reducing the implied user level of the presented choices, thus, it would have an impact on the display simplification **2103**, with only the necessary changes in the current user level **2101**.

It is noted that, the adaptive user level interface is of use in uncontrolled environments, such as in a moving vehicle, especially for use by a driver. An intelligent system of the present invention would allow the driver of such a vehicle to execute control sequences, which may compensate for the limited ability to interact with an interface while driving. Thus, the driver need not explicitly control all individual elements, because the driver is assisted by an intelligent interface. Thus, for example, if it begins raining, the interface would predict the windshield wipers should be actuated, the windows and any roof opening closed, and possibly the headlights activated. Thus, the driver could immediately assent to these actions, without individually actuating each control. In such a case, the screen interface would provide a small number of choices, which may be simply selected. Further, under such conditions, there would likely be a large amount of jitter from the input device, which would be filtered to ease menu selection. Further, this jitter would indicate an unstable environment condition, which would cause the interface to present an appropriate display.

Likewise, the present interface could be used to control complex telecommunications functions of advanced telephone and telecommunications equipment. In such a case, the user display interface would be a video display, or a flat panel display, such as an LCD display. The interface would hierarchically present the available choices to the user, based on a probability of selection by the user. The input device would be, for example, a small track ball near the keypad. Thus, simple telephone dialing would not be substantially impeded, while complex functions, such as call diversion, automated teledictation control, complex conferencing, caller identification-database interaction, and videotel systems, could easily be performed.

EXAMPLE 4

Another aspect of the present invention relates to the cataloging and indexing of the contents of a storage medium. While random access media normally incorporate a directory of entries on a disk, and devices such as optical juke boxes normally are used in conjunction with software that indexes the contents of the available disks, serial access mass storage devices, such as magnetic tape, do not usually employ an index; therefore, the entire tape must be searched in order to locate a specific selection.

In the present invention, an area of the tape, preferable at the beginning of the tape or at multiple locations therein, is encoded to hold information relating to the contents of the tape. This encoding is shown in FIG. **19**, which shows a data format for the information. This format has an identifying header **1901**, a unique tape identifier **1902**, an entry identifier **1903**, a start time **1904**, an end time **1905** and/or a duration **1906**, a date code **1907**, a channel code **1908**, descriptive information **1909** of the described entry, which may include recording parameters and actual recorded locations on the tape, as well as a title or episode identifying information, which may be a fixed or variable length entry, optionally representative scenes **1910**, which may be analog, digital, compressed form, or in a form related to the abstract characterizations of the scenes formed in the operation of the device. Finally, there are error correcting codes **1911** for the catalog entry, which may also include advanced block encoding schemes to reduce the affect of non-Gaussian correlated errors which may occur on video tape, or other transmission media. This information is preferably a modulated digital signal, recorded on, in the case of Hi-Fi VHS, one or more of the preexisting tracks on the tape, including the video, overscan area, Audio, Hi-Fi stereo audio, SAP or control tracks. It should be noted that an additional track could be added, in similar fashion to the overlay of Hi-Fi audio on the video tracks of Hi-Fi VHS. It is also noted that similar techniques could be used with Beta format, 8 mm, or other recording systems, to provide the necessary indexing functions.

The recording method is preferable a block encoding method with error correction within each block, block redundancy, and interleaving. Methods are known for reducing the error rate for digital signals recorded on unverified media, such as videotape, which are subject to burst errors and long term non-random errors. Such techniques reduce the effective error rate to acceptable levels. These are known to those skilled in the art and need not be discussed herein in detail. A standard reference related to this topic is *Digital Communications* by John G. Proakis, McGraw-Hill (1983), which is incorporated herein by reference. The digital data recording scheme is best determined according to the characteristics of the recording apparatus. Therefore, if an, e.g. Sony Corporation helical scan recording/reproducing apparatus was employed, one of ordinary skill in the art would initially reference methods of the Sony Corporation initially for an optimal error correcting recording scheme, which are available in the patent literature, in the U.S., Japan, and internationally, and the skilled artisan would also review the known methods used by other manufacturers of digital data recording equipment. Therefore, these methods need not be explained herein in detail.

The catalog of entries is also preferably stored in non-volatile memory, such as hard disk, associated with the VCR controller. This allows the random selection of a tape from a library, without need for manually scanning the contents of each tape. This also facilitates the random storage of recordings on tape, without the requirement of storing related entries in physical proximity with one another so that they may be easily located. This, in turn, allows more efficient use of tape, because of reduced empty space at the end of a tape. The apparatus is shown schematically in FIG. **20**, in which a tape drive motor **2001**, controlled by a transport control **2002**, which in turn is controlled by the control **2003**, moves a tape **2005** past a reading head **2004**. The output of the reading head **2004** is processed by the amplifier/demodulator **2006**, which produces a split output signal. One part of the output signal comprises the analog signal path **2007**, which is described elsewhere. A digital reading circuit **2008** transmits the digital information to a digital information detecting circuit **2009**, which in turn decodes the information and provides it to the control **2003**.

In order to retrieve an entry, the user interacts with the same interface that is used for programming the recorder functions; however, the user selects different menu selections, which guide him to the available selections. This function, instead of focusing mainly on the particular user's history in order to predict a selection, would analyze the entire library, regardless of which user instituted the recording. Further, there would likely be a bias against performing identically the most recently executed function, and rather the predicted function would be an analogous function, based on a programmed or inferred user preference. This is because it is unlikely that a user will perform an identical action repeatedly, but a pattern may still be derived.

It is noted that the present library functions differ from the prior art VHS tape index function, because the present index is intelligent, and does not require the user to mark an index location and explicitly program the VCR to shuttle to that location. Rather, the index is content based. Another advantage of the present library function is that it can automatically switch media. Such a system might be used, for example, if a user wishes to record, e.g., "The Tonight Show With Johnny Carson" in highly compressed form, e.g. MPEG at 200:1 compression, except during the performance of a musical guest, at which time the recording should be as lossless as possible. A normal VCR could hardly be used to implement such a function even manually, because the tape speed (the analogy of quality level) cannot be changed in mid recording. The present system could recognize the desired special segment, record it as desired, and indicate the specific parameters on the information directory. The recorded information may then be retrieved sequentially, as in a normal VCR, or the desired selection may be preferentially retrieved. If the interface of the present invention is set to automatically record such special requests, the catalog section would then be available for the user to indicate which selections were recorded based upon the implicit request of the user. Because the interface has the ability to characterize the input and record these characterizations in the index, the user may make an explicit request different from the recording criteria, after a selection has been recorded. The controller would then search the index for matching entries, which could then be retrieved based on the index, and without a manual search of the entire tape. Other advantages of the present system are obvious to those of ordinary skill in the art.

A library system is available from Open Eyes Video, called "Scene Locator", which implements a non-intelligent system for indexing the contents of a videotape. See NewMedia, November/December 1991, p. 69.

It is noted that, if the standard audio tracks are used to record the information, then standard audio frequency modems and recording/receiving methods are available. These standard modems range in speed from 300 baud to 19,200 baud, e.g. v.FAST, v.32bis, etc. While these systems are designed for dial-up telecommunications, and are therefore slower than necessary and incorporate features unnecessary for closed systems, they require a minimum of design effort and the same circuitry may be multiplexed and also be used for telecommunication with an on-line database, such as a database of broadcast listings, discussed above.

The Videotext standard may also be used to record the catalog or indexing information on the tape. This method, however, if used while desired material is on the screen, makes it difficult to change the information after it has been recorded, because the videotext uses the video channel, during non-visible scan periods thereof.

The use of on-line database listings may be used by the present interface to provide information to be downloaded and incorporated in the index entry of the library function, and may also be used as part of the intelligent determination of the content of a broadcast. This information may further be used for explicitly programming the interface by the user, in that the user may be explicitly presented with the available choices available from the database.

EXAMPLE 5

The present invention may incorporate character recognition from the video broadcast for automatic entry of this information. This is shown schematically in FIG. **24**, with the inclusion of the videotext and character recognition module **2414**. This information is shown to be transmitted to the event characterization unit **2407**, where the detected information is correlated with the other available information. This information may also be returned to the control **2402**. Examples of the types of information which would be recognized are titles of shows, cast and crew from programming material, broadcast special alerts, time (from digital display on special access channels), stock prices from "ticker tape" on special access channels, etc. Thus, this technology adds functionality to the interface. In addition, subtitled presentations could be recognized and presented through a voice synthesizer, to avoid the necessity of reading the subtitle. Further, foreign language subtitles could be translated into, e.g., English, and presented.

The character recognition is performed in known manner on a buffer memory containing a frame of video, from a device such as a Data Translation DT2851, DT2853, DT2855, DT2867, DT2861, DT2862 and DT2871. A contrast algorithm, run on, for example, a Data Translation DT2858, DT2868, or DT2878, first removes the background, leaving the characters. This works especially well where the characters are of a single color, e.g. white, so that all other colors are masked. After the "layer" containing the information to be recognized is masked, an algorithm similar to that used for optical character recognition (OCR) is employed. These methods are well known in the art. This may be specially tuned to the resolution of the video device, e.g. NTSC, S-VHS, IDTV, Enhanced Definition Television (EDTV) MUSE, PAL, SECAM, etc. In addition, since the text normally lasts for a period in excess of one frame, a spatial-temporal image enhancement algorithm may be employed to improve the quality of the information to be recognized.

EXAMPLE 6

The present invention may also be incorporated into other types of programmable controls, for example those necessary or otherwise used in the control of a smart house. See, "The Smart House: Human Factors in Home Automation", Human Factors in Practice, December 1990, 1–36. The user interface in such a system is very important, because it must present the relevant data to the user for programming the control to perform the desired function. A smart house would likely have many rarely used functions, so that the presentation of both the data and the available program options must be done in the simplest manner consistent with the goal of allowing the user to make the desired program choice. For example, a smart house system might be used to execute the program "start dishwasher, if more than half full, at 9:00 p.m." A user who wishes to delay starting until 11:00 p.m. would be initially presented with the default time as an option, which would be simply modified by correcting the starting time. The next time the user wishes to program the device, an algorithm would change the predicted starting time to, e.g. 10:00 p.m., which is a compromise between the historical choices.

The smart house system also controls the climate control system. Thus, it could coordinate temperatures, air flow and other factors, based on learned complex behaviors, such as individual movement within the dwelling. Since the goal of the programming of the smart house is not based on the storage of discrete information, but rather the execution of control sequences at various times and under certain circumstances, the control would differ in various ways from that of a VCR. However, the user interface system, adaptive user level, help system, and other human interface elements would be common to both types of system. This differs from the Fuzzy Logic controlled air conditioner available (in Japan) from Mitsubishi in that that device does not have an intelligent interface of the present invention. It should also be noted that the control for the VCR could be the same control as that for the smart house, so that the common elements are not redundant. Therefore, by applying a single control to many tasks, a common user interface is used, and the cost is reduced.

EXAMPLE 7

The present Example relates to a programmable environmental controller application. In this case, a sensor or sensor array is arranged to detect a change in the environment which is related to a climatic condition, such as an open door. On the occurrence of the door opening, the system would apply a pattern recognition analysis to recognize this particular sensor pattern, i.e. a mass of air at a different temperature entering the environment from a single location, or a loss of climate controlled air to a single location. These sensor patterns must be distinguished from other events, such as the action of appliances, movement of individuals in the vicinity of the sensor, a shower and other such events. It is noted that in this instance, a neural network based adaptive controller may be more efficient, because the installation and design of such a system is custom, and therefore it would be difficult to program a priori. In this case, a learning system, such as a neural network, may be more efficient and produce a better result than other adaptive methods. The training procedure could be fully automated, so long as sufficient sensors are provided for controlling the system, and also that an initial presumption of the control strategy is workable during the training period. In this case, the initial strategy incorporated is the prior art "bang-bang" controller, which operates as a simple thermostat, or multi-zone thermostat. As a better starting point, a fuzzy logic temperature controller may be modeled and employed. Other known strategies which are not often used in environmental control include the proportional-integral-differential controller (PID).

In this example, which may be described with reference to FIG. **23**, sufficient sensors in a sensor array **2301** are provided, being light, temperature, humidity, pressure, air flow and possibly a sensor for determining an event proximate to the sensor, such as door opening. While a single sensor array **2301** could provide input to the present control, a plurality of sensor arrays are preferably employed in complex installations, such as that described here. The sensors, with the possible exceptions of the flow sensor and event sensor, are housed in a single sensor head. Further, the temperature and pressure sensors may be combined in a single integrated circuit by known methods. The light and temperature sensors are known to those skilled in the art, and need not be described herein. The pressure sensor may be a Sensym strain gage pressure transducer, a Motorola pressure transducer device, or other known pressure transducer, and may also be a derivative of the Analog Devices monolithic accelerometer. These devices are known in the art. The humidity sensor is preferably an electronic type, producing an electrical signal output. It need not be internally compensated for the other measured environmental factors. The air flow sensor may be based on pressure differentials, using the pressure sensor described above, or may be a mechanical vane type. In most applications, a single flow axis will be sufficient, however, in some circumstances, a two or greater axis sensor will be required. Further, in the case of large volume areas, complex turbulent flow patterns may be relevant, for which known sensors exist. The event sensor may be of any type, and depends particularly on the event being measured. In the present case, where a door opening is to be detected, it is preferred that the environmental control be interfaced with a perimeter intrusion alarm system, which, for example, provides a magnet embedded in the door and a magnetic reed switch in the door frame. Individual sensors are normally wired to the alarm control panel, thus providing central access to many or all of the desired event detection sensors while minimizing the added cost. The event detector may also be an ultrasonic, infrared, microwave-doppler, mechanical, or other type of sensor.

The preferred method of receiving sensor information is through a serial digital or multiplexed analog (i.e., 4–20 mA transmitter) data transmission scheme, with minimal local processing of the sensor data by the microprocessor **2302** with the serial link **2302***a* in the sensor head. This system allows the central control **2303** to incorporate the desired processing, e.g., by the pattern recognition system **2304**, etc., while minimizing the installation expense. A simple microprocessor device **2302** in the sensor head interfaces the sensing elements, and may provide analog-to-digital conversion, or other conversion which may be necessary, of the sensor signal. In the case of a serial digital data transmission, the local microprocessor formats the sensor data, including a code indicating the sensor serial number and type, the sensor status (i.e., operative, defective, in need of maintenance or calibration, etc.), the sensor data, and an error correcting code. In the case that the data is transmitted on a local area network, the microprocessor also arbitrates for bus usage and the messaging protocol.

The control, it must be understood, has a number of available operative systems at its disposal, comprising the plant **2306**. In this case, the system is a forced air heating and cooling system. This system has a heating unit, a humidifier, blowers, a cooling unit (which also dehumidifies), ducts, dampers, and possible control over various elements, such as automated door openers.

As described above, the system is installed with a complete array of sensors, some of which may be shared with other control systems in the environment, and begins operation with a basic acceptable initial control protocol. The system then receives data from the sensors, and correlates data from the various sensors, including the event sensors, with the operation of the systems being controlled. In such a case, a "door open" event may be correlated with a change in other measured variables. The system then correlates the control status with the effect on the interrelation of the measured variables. Thus, the system would detect that if the blower is operating while the door is open, then there is a high correlation that air will flow out of the door, unless a blower operates to recirculate air from a return near the door. Thus, the system will learn to operate the proximate return device while the door is open and the blower is on. Once this correlation is defined, the system may further interrelate the variables, such as a wind speed and direction outside the door, effects of other events such as other open doors, the absolute and relative speeds of the blowers and the return device, the effect of various damper devices, etc. It is further noted that, under some circumstances, an exchange of air through an open door is desired, and in such instance, the system may operate to facilitate the flow through such an open door. Finally, the system must be able to "learn" that conditions may exist which produce similar sensor patterns which should be handled differently. An example is a broken or inoperative sensor. In such a case, the system must be able to distinguish the type of condition, and not execute an aggressive control algorithm in an attempt to compensate for an erroneous reading or otherwise normal event. This requires the intelligent control of the present invention.

It is further noted that energy efficiency is a critical issue in climate control systems, and an absolute and continuous control over the internal environment may be very inefficient. Thus, the starting of large electrical motors may cause a large power draw, and simultaneous starting of such equipment may increase the peak power draw of a facility, causing an increase in the utility rates. Further, some facilities may operate on emergency or private power generation (co-generation) which may have different characteristics and efficiency criteria. These must all be considered in the intelligent control. It is also noted that a higher efficiency may also be achieved, in certain circumstances, by employing auxiliary elements of the climate control system which have a lower capacity and lower operating costs than the main elements. Thus, for example, if one side of a building is heated by the sun, it may be more efficient to employ an auxiliary device which suitably affects only a part of the building. Thus, if such equipment is installed, the aggregate efficiency of the system may be improved, even if the individual efficiency of an element is lower. The present intelligent control allows a fine degree of control, making use of all available control elements, in an adaptive and intelligent manner.

Returning to the situation of a door opening event, the system would take appropriate action, including: interruption of normal climate control until after the disturbance has subsided and normal conditions are achieved; based on the actual climatic conditions or predicted climatic conditions begin a climate compensation control, designed to maximize efficiency and also maintain climatic conditions during the disturbance, as well as return to normal after the disturbance; optionally, during the door opening disturbance, the system would control a pressure or flow of air to counterbalance a flow through the door, by using a fan, blower or other device, or halting such a device, if necessary. It is also noted that the climatic control system could also be outfitted with actuators for opening and closing doors and windows, or an interface with such other system, so that it could take direct action to correct the disturbance, e.g., by closing the door. The climate between the internal and external ambients may differ in temperature, humidity, pollutants, or other climatic conditions, and appropriate sensors may be employed.

It is thus realized that the concepts of using all available resources to control an event, as well as using a predictive algorithm in order to determine a best course of action and a desired correction are a part of the present invention.

EXAMPLE 8

A remote control of the present invention may be constructed from, for example, a Micromint (Vernon, Conn.) RTC-LCD, RTC-V25 or RTC-HC11 or RTC180 or RTC31/52, and RTC-SIR, in conjunction with an infrared transmitter and receiver, input keys and a compatible trackball, which may provide raw encoder signals, or may employ a serial encoder and have a serial interface to the processor module. A power supply, such as a battery, is used. The use, interfacing and programming of such devices is known to those skilled in the art, and such information is generally available from the manufacturer of the boards and the individual circuit elements of the boards. The function of such a remote control is to receive inputs from the trackball and keys and to transmit an infrared signal to the controller. The processor and display, if present, may provide added functionality by providing a local screen, which would be useful for programming feedback and remote control status, as well as compressing the data stream from the trackball into a more efficient form. In this case, certain of the extracted information may be relevant to the determination of the user level, so that information related to the user level would be analyzed and transmitted separately to the controller by the infrared transmitter. If the local LCD screen is used in the programming process, then the main controller would transmit relevant information to the remote display, by a reverse infrared link. These components are known in the art, and many other types may also be used in known manner.

EXAMPLE 9

The interface and intelligent control of the present invention are applicable to control applications in medicine or surgery. This system may also be described with reference to the generic system drawings of FIGS. **23** and **24**. In this case, an operator identifies himself and enters information regarding the patient, through the interface **2305**. The interface **2305** automatically loads the profile **2406** of both the operator and the patient, if the device is used for more than one at a time, and is connected to a database containing such information, such as a hospital central records bureau. The interface may be connected to various sensors, of the input device **2401**, such as ambient conditions (temperature, humidity, etc.), as well as data from the patient, such as electrocardiogram (EKG or ECG), electromyograph (EMG), electroencephalogram (EEG), Evoked Potentials, respirator, anesthesia, temperature, catheter status, arterial blood gas monitor, transcutaneous blood gas monitor, urinary output, intravenous (IV) solutions, pharmaceutical and chemotherapy administration data, mental status, movement, pacemaker, etc. as well as sensors and data sources separate from the patient such as lab results, radiology and medical scanner data, radiotherapy data and renal status, etc. Based on the available information, the interface **2405**, using the simple input device and the display screen described above, presents the most important information to the operator, along with a most probable course of action. The user then may either review more parameters, investigate further treatment options, input new data, or accept the presented option(s). The system described has a large memory in the signal analysis module **2409** for recording available patient data from the signal receiver **2408**, and thus assists in medical record keeping and data analysis, as well as diagnosis. While various systems are available for assisting in both controlling medical devices and for applying artificial intelligence to assist in diagnosis, the present system allows for individualization based on both the service provider and the patient. Further, the present invention provides the improved interface for interaction with the system. It is further noted that, analogously to the library function discussed above, medical events may be characterized in the characterization unit **2407** and recorded by the plant **2404**, so that a recording of the data need not be reviewed in its entirety in order to locate a particular significant event, and the nature of this event need not be determined in advance. It is also noted that the compression feature of the recorder of the present invention could be advantageously employed with the large volume of medical data that is often generated. It is finally noted that, because of its ability to store and correlate various types of medical data in the characterization unit **2407**, the system could be used by the operator to create notes and discharge summaries for patients, using the database stored in the local database **2413**, as well as the user history and preferences **2406**. Thus, in addition to saving time and effort during the use of the device, it would also perform an additional function, that of synthesizing the data, based on medical significance.

In addition to providing the aforementioned intelligence and ease of use, the present example also comprises a control **2402**, and may interface with any of the sensors and devices, performing standard control and alarm functions. However, because the present control **2402** is intelligent and has pattern recognition capability, in addition to full data integration from all available data sources, it may execute advanced control functions. For example, if the present control **2402** is interfaced to a controlled infusion pump for, e.g., morphine solution, in e.g., a terminally ill patient, then certain parameters must be maintained, while others may be flexible. For example, a maximum flow rate is established as a matter of practice as a safety measure; too high a flow rate could result in patient death. However, a patient may not need a continuous infusion of a constant dose of narcotic. Further, as the patient's status changes, the level of infusion may be advantageously altered. In particular, if the renal status of the patient were to change, the excretion of the drug may be impaired. Therefore, if the controller had a urinary output monitor, it could immediately suppress the morphine infusion as soon as the renal output is recognized as being decreased, and further indicate an alarm condition. Further, it may be advantageous to provide a diurnal variation in the infusion rate, to provide a "sleep" period and a period of heightened consciousness with correspondingly lower levels of narcosis.

As another example of the use of the present device as a medical controller, the control **2402** could be interfaced with a cardiac catheter monitor, as a part of the signal receiver **2408**. In such a case, normally, alarms are set based on outer ranges of each sensor measurement, and possibly a simple formula relating two sensor measurements, to provide a useful clinical index. However, by incorporating the advanced interface and pattern recognition function of the present invention, as well as its ability to interface with a variety of unrelated sensors, the present device, including the present control, may be more easily programmed to execute control and alarm functions, may provide a centralized source of patient information, including storage and retrieval, if diverse sources of such information are linked, and may execute advanced, adaptive control functions. The present control **2402** is equipped to recognize trends in the sensor data from the signal receiver **2408**, which would allow earlier recognition and correction of various abnormal conditions, as well as recognizing improvements in conditions, which could allow a reduction in the treatment necessary. Further, by allowing a fine degree of control, parameters may be maintained within optimal limits for a greater percentage of the time. In addition, by monitoring various sensors, various false alarms may be avoided or reduced. In particular, false alarms may occur in prior art devices even when sensors do not indicate a dangerous condition, merely as a safety precaution when a particular parameter is out of a specified range. In such a case, if a cause of such abnormal condition may be identified, such as patient movement or the normal activities of the patient's caretakers, then such condition may be safely ignored, without indicating an alarm. Further, even if a sensor parameter does in and of itself indicate a dangerous condition, if a cause, other than a health risk, may be identified, then the alarm may be ignored, or at least signalled with a different level of priority. By providing an intelligent and active filter for false alarm events, the system may be designed to have a higher level of sensitivity to real health risks, and further to provide a finer level of control based on the sensor readings.

EXAMPLE 10

The present invention is also of use in automated securities, debt, variable yield and currency trading systems, where many complex functions are available, yet often a particular user under particular circumstances will use a small subset of the functionality available at a given time. Such a situation would benefit from the present interface, which provides adaptive user levels, prioritized screen information presentation, and pattern recognition and intelligent control. A securities trading system is disclosed in U.S. Pat. No. 5,034,916, for a mouse driven Fast Contact Conversational Video System, incorporated herein by reference. The present system relates primarily to the user terminal, wherein the user must rapidly respond to external events, in order to be successful. In such a case, the advantages of the interface aspects are obvious, and need not be detailed herein. However, the pattern recognition functions of the present invention may be applied to correspond to the desired actions of the trader, unlike in prior intelligent trading systems, where the terminal is not individually and adaptively responsive to the particular user. Thus, the system exploits the particular strengths of the user, facilitating his actions, including: providing the desired background information and trading histories, in the sequence most preferred by the user; following the various securities to determine when a user would execute a particular transaction, and notifying the user that such a condition exists; monitoring the success of the user's strategy, and providing suggestions for optimization to achieve greater gains, lower risk, or other parameters which may be defined by the user. Such a system, rather than attempting to provide a "level playing field", allows a user to use his own strategy, providing intelligent assistance.

EXAMPLE 11

The fractal method employing Affine transforms may be used to recognize images. This method proceeds as follows. A plurality of templates are stored in a memory device, which represent the images to be recognized. These templates may be preprocessed, or processed in parallel with the remainder of the procedure, in a corresponding manner. Image data, which may be high contrast line image, greyscale, or having a full color map, the greyscale being a unidimensional color map, is stored in the data processor, provided for performing the recognition function. A plurality of addressable domains are generated from the stored image data, each of the domains representing a portion of the image information. It is noted that the entire image need not be represented, only those parts necessary for the recognition, which may be determined by known methods. From the stored image data, a plurality of addressable mapped ranges are created, corresponding to different subsets of the stored image data. Creating these addressable mapped ranges, which should be uniquely addressable, also entails the step of executing, for each of the mapped ranges, a corresponding procedure upon the one of the subsets of the stored image data which corresponds to the mapped ranges. Identifiers are then assigned to corresponding ones of the mapped ranges, each of the identifiers specifying, for the corresponding mapped range, a procedure and a address of the corresponding subset of the stored image data. The treatment of the template and the image data is analogous, so that the resulting data is comparable. The domains are optionally each subjected to a transform, which may be a predetermined rotation, an inversion, a predetermined scaling, and a predetermined frequency domain preprocessing transform. This transform is used to optimize the procedure, and also to conform the presentation of the image data with the template, or vice versa. Each of the domains need not be transformed the same way. For each of the domains or transformed domains, as may be the case, the one of the mapped ranges which most closely corresponds according to predetermined criteria, is selected. The image is then represented as a set of the identifiers of the selected mapped ranges. Finally, from the stored templates, a template is selected which most closely corresponds to the set of identifiers representing the image information. It is preferred that, for each domain, a most closely corresponding one of the mapped ranges be selected. By performing analogous operations on a template and an unrecognized object in an image, a correspondence between the two may be determined.

In selecting the most closely corresponding one of the mapped ranges, for each domain, the mapped range is selected which is the most similar, by a method which is appropriate, and may be, for example, selecting minimum Hausdorff distance from the domain, selecting the highest cross-correlation with the domain, the minimum mean square error with the domain and selecting the highest fuzzy correlation with the domain. Neural network energy minimization may also yield the best fit, and other techniques may also be appropriate.

In particular, the step of selecting the most closely corresponding one of mapped ranges according to the minimum modified Hausdorff distance includes the step of selecting, for each domain, the mapped range with the minimum modified Hausdorff distance calculated as D[db,mrb]+D[1−db,1−mrb], where D is a distance calculated between a pair of sets of data each representative of an image, db is a domain, mrb is a mapped range, 1−db is the inverse of a domain, and 1−mrb is an inverse of a mapped range.

In the case where the digital image data consists of a plurality of pixels, each having one of a plurality of associated color map values, the method includes a matching of the color map, which as stated above, includes a simple grey scale. In such a case, the method is modified to optionally transform the color map values of the pixels of each domain by a function including at least one scaling function, for each axis of said color map, each of which may be the same or different, and selected to maximize the correspondence between the domains and ranges to which they are to be matched. For each of the domains, the one of the mapped ranges having color map pixel values is selected which most closely corresponds to the color map pixel values of the domain according to a predetermined criteria, wherein the step of representing the image color map information includes the substep of representing the image color map information as a set of values each including an identifier of the selected mapped range and the scaling functions. The correspondence method may be of any sort and, because of the added degree of complexity, may be a different method than that chosen for non-color images. The method of optimizing the correspondence may be minimizing the Hausdorff distance or other "relatedness" measurement between each domain and the selected range. The recognition method concludes by selecting a most closely corresponding stored template, based on the identifier of the color map mapped range and the scaling functions, which is the recognized image.

In the case of moving images, the method is further modified to accommodate time varying images. These images usually vary by small amounts between frames, and this allows a statistical improvement of the recognition function by compensating for a movement vector, as well as any other transformation of the image. This also allows a minimization of the processing necessary because redundant information between successive frames is not subject to the full degree of processing. Of course, if the image is substantially changed, then the statistical processing ceases, and a new recognition function may be begun, "flushing" the system of the old values. The basic method is thus modified by storing delayed image data information, i.e., a subsequent frame of a moving image. This represents an image of a moving object differing in time from the image data in the data processor. A plurality of addressable further domains are generated from the stored delayed image data, each of the further domains representing a portion of the delayed image information, and corresponding to a domain. Thus, an analogous transform is conducted so that the further domains each are corresponding to a domain. A plurality of addressable mapped ranges corresponding to different subsets of the stored delayed image data are created from the stored delayed image data. The further domain and the domain are optionally matched by subjecting a further domain to a corresponding transform selected from the group consisting of a predetermined rotation, an inversion, a predetermined scaling, and a predetermined frequency domain preprocessing transform, which corresponds to a transform applied to a corresponding domain, and a non-corresponding transform selected from the group consisting of a predetermined rotation, an inversion, a predetermined scaling, a translation and a predetermined frequency domain preprocessing transform, which does not correspond to a transform applied to a corresponding domain. For each of the further domains or transformed further domains, the one of the mapped ranges is selected which most closely corresponds according to predetermined criteria. A motion vector is then computed between one of the domain and the further domain, or the set of identifiers representing the image information and the set of identifiers representing the delayed image information, and the motion vector is stored. The further domain is compensated with the motion vector and a difference between the compensated further domain and the domain is computed. For each of the delayed domains, the one of the mapped ranges is selected which most closely corresponds according to predetermined criteria. The difference between the compensated further domain and the domain is represented as a set of difference identifiers of the selected mapping ranges and an associated motion vector.

This method is described with respect to FIGS. **27**, **28** and **29**. FIG. **27** is a basic flow diagram of the recognition system of the present invention. FIG. **28** provides a more detailed description, including substeps, which are included in the major steps shown in FIG. **27**. Basically, the image, or a part thereof, is decomposed into a compressed coded version of the scene, by a modified fractal-based compression method. In particular, this differs from the prior compression algorithms in that only a part, preferably that part containing objects of interest, need be processed. Thus, if a background is known (identified) or uninteresting, it may be ignored. Further, the emphasis is on matching the available templates to produce an image recognition, not achieving a high degree of compression. Therefore, the image, or domains thereof, may be transformed as required in order to facilitate the matching of the templates. As with respect to single images, the templates are represented in analogous form, having been processed similarly, so that a comparison of the relatedness of an object in an image and the templates may be performed. In particular, if an oblique view of an object is presented, then either the object may be transformed to achieve a predicted front view, or the template transformed or specially selected to correspond to the oblique view. Further, once a recognition has taken place with a high degree of certainty, the system need only ensure that the scene has not changed, and need not continually process the data. This has implications where multiple recognition processes are occurring simultaneously, either in a single scene or in different images, wherein the throughput of the recognition apparatus need not meet that required for de novo recognition of all aspects of all the objects or images.

FIG. **30** shows a flow diagram of a cartoon-like representation of an image recognition method of the present invention. It shows initially, an input image **3001**, having a degree of complexity. A windowing function **3002** isolates the object from the background. A first order approximation of the image is generated **3003**, here called a mapping region. The first order approximation is then subtracted from the initial image to produce a difference **3004**. The first order error is then subjected, iteratively, to successive transform and subtract operations **3005** and **3006**, until the error is acceptably small, at which point the input image is characterized by a series of codes, representing the first order approximation and the successive transforms, which are stored **3008**. These codes are then compared with stored templates **3009**. The comparisons are then analyzed to determine which template produces the highest correlation **3010**, and the match probability is maximized **3011**. The recognized image is then indicated as an output **3012**.

This system is shown in FIG. **26**, wherein a sensor **2602** provides data, which may be image data, to a control **2601**. The control **2601** serves to control the plant **2603**, which has an actuator. The plant **2603** is in this case a VCR. The control **2601** has associated with it an intermediate sensor data storage unit **2611**, which may be, for example a frame buffer. The control **2601** also has associated with it a transform engine **2612**, which may perform a reversible or irreversible transform on the data or stored data.

The system also has a template input **2610**, which may receive data from the sensor **2602**, if accompanied by identifying information. Thus, the pattern storage memory **2609** stores a pattern, such as an image pattern, along with an identifier.

The control **2601** also has an input device **2604**, an on-screen display interface **2605**, and a program memory **2606**, for inputting instructions from a user, providing feedback to the user, and recording the result of the user interaction, respectively. Finally, a characterization network **2607** characterizes the sensor **2602** data, which may be provided directly from the sensor **2602** or preprocessing circuitry, or through the control **2601**. A correlator **2608** correlates the output of the characterization network with the stored patterns, representing the templates from the template input **2610**. The system therefore operates to recognize sensor patterns, based on the correlator **2608** output to the control **2601**.

A determination is made of the complexity of the difference based on a density of representation. In other words, the error between the movement and transform compensated delayed image and the image is quantified, to determine if the compensation is valid, or whether the scene is significantly changed. When the difference has a complexity below a predetermined threshold, a template is selected, from the stored templates, which most closely corresponds or correlates with both the set of identifiers of the image data and the set of identifiers of the delayed image data, thus improving recognition accuracy, by allowing a statistical correlation or other technique. For example, if the two images both have a high correlation with one template, while a first of the images has a slightly higher correlation with another template, while the second image has a much lower correlation with that other template, then the system would score the first template as a better match to the first image.

It should be understood that the preferred embodiments and examples described herein are for illustrative purposes only and are not to be construed as limiting the scope of the present invention, which is properly delineated only in the appended claims.

REFERENCES INCORPORATED BY REFERENCE

"32-bit Floating-Point DSP Processors", EDN, Nov. 7, 1991, pp. 127–146.

"A New Class of Markov Processes for Image Encoding", School of Mathematics, Georgia Inst. of Technology (1988), pp. 14–32.

"Bar Code Programs VCR", Design News, Feb. 1, 1988, 26.

"C-Cube CL550 JPEG Image Compression Processor", Preliminary Data Book, August 1991, and addendum dated Nov. 20, 1991.

"Construction of Fractal Objects with Iterated Function Systems", Siggraph '85 Proceedings, 19(3):271–278 (1985).

"Data Compression: Pntng by Numbrs", The Economist, May 21, 1988.

"EMC^2 Pushes Video Rental By Satellite", Electronic Engineering Times, Dec. 2, 1991, p.1, p. 98.

"Finger Painting", Information Display 12, p. 18, 1981.

"Fractal Modelling of Real World Images, Lecture Notes for Fractals: Introduction, Basics and Perspectives", Siggraph (1987).

"Fractal Geometry-Understanding Chaos"; Georgia Tech Alumni Magazine; p. 16 (Spring 1986).

"Fractal Modelling of Biological Structures", Perspectives in Biological Dynamics and Theoretical Medicine, Koslow, Mandell, Shlesinger, eds., Annals of New York Academy of Sciences, vol. 504, 179–194 (date unknown).

"Fractals Yield High Compression"; Electronic Engineering Times; Sep. 30, 1991; p. 39.

"Fractals-A Geometry of Nature", Georgia Institute of Technology Research Horizons; p. 9 (Spring 1986).

"How to find the best value in VCRs", Consumer Reports, March 1988, 135–141.

"Low-Cost VCRs: More For Less", Consumer Reports, March 1990, 168–172.

"Machine Now Reads, enters Information 25 Times Faster Than Human Keyboard Operators", Information Display 9, p. 18 (1981).

"New Beetle Cursor Director Escapes All Surface Constraints", Information Display 10, p. 12, 1984.

"Nielsen Views VCRs", Television Digest, Jun. 23, 1988, 15.

"Scanner Converts Materials to Electronic Files for PCs", IEEE CG&A, December 1984, p. 76.

"The Highs and Lows of Nielsen Homevideo Index", Marketing & Media Decisions, November 1985, 84–86+.

"The Smart House: Human Factors in Home Automation", Human Factors in Practice, December 1990, 1–36.

"The Quest for 'User Friendly'", U.S. News & World Report, Jun. 13, 1988. 54–56.

"VCR, Camcorder Trends", Television Digest, Vol. 29, March 20, 1989, 16.

"VCR's: A Look At The Top Of The Line", Consumer Reports, March 1989, 167–170.

"VHS Videocassette Recorders", Consumer Guide, 1990, 17–20.

"Voice Recognition and Speech Processing", Elektor Electronics, September 1985, pp. 56–57.

Abedini, Kamran, and Hadad, George, "Guidelines For Designing Better VCRs", Report No. IME 462, Feb. 4, 1987.

Abedini, Kamran, "An Ergonomically-improved Remote Control Unit Design", Interface '87 Proceedings, 375–380.

Aleksander, I.; "Guide to Pattern Recognition Using Random-Access Memories"; Computers and Digital Techniques; 2(1):29–40 (February 1979).

Anderson, F., W. Christiansen, B. Kortegaard; "Real Time, Video Image Centroid Tracker"; Apr. 16–20, 1990.

Anson, L., M. Barnsley; "Graphics Compression Technology"; SunWorld; pp. 43–52 (October 1991).

Appriou, A., "Interet des theories de l'incertain en fusion de donnees", Colloque International sur le Radar Paris, 24–28 avril 1989.

Appriou, A., "Procedure d'aide a la decision multi-informateurs. Applications a la classification multi-capteurs de cibles", Symposium de l'Avionics Panel (AGARD) Turquie, 25–29 avril 1988.

Arrow, K. J., "Social choice and individual valves", John Wiley and Sons Inc. (1963).

Atkinson, Terry, "VCR Programming: Making Life Easier Using Bar Codes".

Baldwin, William, "Just the Bare Facts, Please", Forbes Magazine, Dec. 12, 1988.

Ballard, D. H., and Brown, C. M., Computer Vision, Prentice Hall, Englewood Cliffs, N.J. (1982).

Barnsley et al., "Harnessing Chaos For Images Systhesis", Computer Graphics, 22(4):131–140 (August, 1988).

Barnsley, M. F., Ervin, V., Hardin, D., Lancaster, J., "Solution of an Inverse Problem for Fractals and Other Sets", Proc. Natl. Acad. Sci. U.S.A., 83:1975–1977 (April 1986).

Barnsley, M. F., "Fractals Everywhere", Academic Press, Boston, Mass., 1988,

Barnsley, M. F., and Demko, S., "Iterated Function Systems and The Global Construction of Fractals", Proc. R. Soc. Lond., A399:243–275 (1985).

Barnsley et al., "Hidden Variable Fractal Interpolation Functions", School of Mathematics, Georgia Institute of Technology, Atlanta, Ga. 30332, July, 1986.

Barnsley et al., "A Better Way to Compress Images", Byte Magazine, January 1988, pp. 213–225.

Barnsley et al., "Chaotic Compression", Computer Graphics World, November 1987.

Batchelor, B. G.; "Practical Approach to Pattern Classification"; Plenum Press, London and New York; (1974).

Batchelor, B. G.; "Pattern Recognition, Ideas in Practice"; Plenum Press, London and New York; (1978).

Baxes, Gregory A., "Digital Signal Processing, A Practical Primer", Prentice-Hall, Englewood Cliffs, N.J. (1984).

Bellman, R. E., L. A. Zadeh, "Decision making in a fuzzy environment", Management Science, 17(4) (December 1970).

Bensch, U., "VPV—VIDEOTEXT PROGRAMS VIDEORECORDER", IEEE Transactions on Consumer Electronics, 34(3):788–792 (1988).

Berger, Ivan, "Secrets of the Universals", Video, February 1989, 45–47+.

Beringer, D. B., "A Comparative Evaluation of Calculator Watch Data Entry Technologies: Keyboards to Chalkboards", Applied Ergonomics, December 1985, 275–278.

Bhatnagar, R. K., L. N. Kamal, "Handling uncertain information: a review of numeric and non-numeric methods", Uncertainty in Artificial Intelligence, L. N. Kamal and J. F. Lemmer, Eds. (1986).

Bishop, Edward W., and Guinness, G. Victor Jr., "Human Factors Interaction with Industrial Design", Human Factors, 8(4):279–289 (August 1966).

Blair, D., R. Pollack, "La logique du choix collectif" Pour la Science (1983).

Brown, Edward, "Human Factors Concepts For Management", Proceedings of the Human Factors Society, 1973, 372–375.

Bulkeley, Debra, "The Smartest House in America", Design News, Oct. 19, 1987, 56–61.

Burr, D. J.; "A Neural Network Digit Recognizer"; Proceedings of the 1986 IEEE International Conference of Systems, Man and Cybernetics, Atlanta, Ga.; pp. 1621–1625.

Caffery, B.; "Fractal Compression Breakthrough for Multimedia Applications"; Inside; Oct. 9, 1991.

Card, Stuart K., "A Method for Calculating Performance times for Users of Interactive Computing Systems", IEEE, 1979, 653–658.

Carlson, Mark A., "Design Goals for an Effective User Interface", Human Interfacing with Instruments, Electro/82 Proceedings, 3/1/1–3/1/4.

Carpenter, G. A., S. Grossberg, "The Art of Adaptive Pattern Recognition by a Self-Organizing Neural Network," IEEE Computer, March 1988, pp. 77–88.

Carroll, Paul B., "High Tech Gear Draws Cries of "Uncle", Wall Street Journal, April 27, 1988, 29.

Casasent, D., et al.;, "General I and Q Data Processing on a Multichannel AO System"; Applied Optics; 25(18) :3217–24 (Sep. 15, 1986).

Casasent, D., Photonics Spectra, November 1991, pp. 134–140.

Casasent, D., and Tescher, A., Eds., "Hybrid Image and Signal Processing II", Proc. SPIE Technical Symposium, April 1990, Orlando Fla. 1297 (1990).

Caudill, M.; "Neural Networks Primer-Part III"; AI Expert; June 1988; pp. 53–59.

Chao, J. J., E. Drakopoulos, C. C. Lee, "An evidential reasoning approach to distributed multiple hypothesis detection", Proceedings of the 20th Conference on decision and control, Los Angeles, Calif., December 1987.

Chen et al.; "Adaptive Coding of Monochrome and Color Images"; November 1977; pp. 1285–1292.

Cobb, Nathan, "I don't get it", Boston Sunday Globe Magazine, Mar. 25, 1990, 23–29.

Computer Visions, Graphics, and Image Processing 1987, 37:54–115.

Computers and Biomedical Research 5, 388–410 (1972).

Cooper, L. N.; "A Possible Organization of Animal Memory and Learning"; Nobel 24; (1973); Collective Properties of Physical Systems; pp. 252–264 Crawford et al.; "Adaptive Pattern Recognition Applied To An Expert System For Fault Diagnosis In Telecommunications Equipment"; pp. 10/1–8 (Inspec. Abstract No. 86C010699, Insepc IEE (London) & IEE Coll. on "Adaptive Filters", Digest No. 76, Oct. 10, 1985)

Danielsson, Erik, et al.; "Computer Architectures for Pictorial Inf. Systems"; IEEE Computer, November, 1981; pp. 53–67.

Davis, Fred, "The Great Look-and-Feel Debate", A+, 5:9–11 (July 1987).

Dehning, Waltraud, Essig Heidrun, and Maass, Susanne, The Adaptation of Virtual Man-Computer Interfaces to User Requirements in Dialogs, Germany, Springer-Verlag, 1981.

Dempster, A. P., "A generalization of Bayesian inference", Journal of the Royal Statistical Society, Vol. 30, Series B (1968).

Dempster, A. P., "Upper and lower probabilities induced by a multivalued mapping", Annals of mathematical Statistics, no. 38 (1967).

Denker; 1984 International Test Conf., October 1984, Philadelphia, Pa.; pp. 558–563.

Derra, Skip, "Researchers Use Fractal Geometry, . . . ", Research and Development Magazine, March 1988.

Donovan, J., "Intel/IBM's Audio-Video Kernel", Byte, December, 1991, pp. 177–202.

Dubois, D., N. Prade, "Fuzzy sets and systems-Theory and applications", Academic Press, New York (1980).

Dubois, D.; "Modeles mathematiques de l'imprecis et de l'incertain en vue d'applications aux techniques d'aide a la decision"; Doctoral Thesis, University of Grenoble (1983).

Dubois, D., N. Prade, "Combination of uncertainty with belief functions: a reexamination", Proceedings 9th International Joint Conference on Artificial Intelligence, Los Angeles (1985).

Dubois, D., N. Prade, "Theorie des possibilites: application a la representation des connaissances en informatique", Masson, Paris (1985).

Duda, R. O., P. E. Hart, M. J. Nilsson, "Subjective Bayesian methods for rule-based inference systems", Technical Note 124-Artificial Intelligence Center-SRI International.

Dunning, B. B.; "Self-Learning Data-Base For Automated Fault Localization"; IEEE; 1979; pp. 155–157.

Ehrenreich, S. L., "Computer Abbreviations—Evidence and Synthesis", Human Factors, 27(2):143–155 (April 1985).

Electronic Engineering Times (EET), Oct. 28, 1991, p. 62.

Elton, J., "An Ergodic Theorem for Iterated Maps", Journal of Ergodic Theory and Dynamical Systems, 7 (1987).

Farrelle, Paul M. and Jain, Anil K.; "Recursive Block Coding—A New Approach to Transform Coding"; IEEE Transactions on Communications, Com. 34(2) (February 1986).

Fitzpatrick, J. M., J. J. Grefenstette, D. Van Gucht; "Image Registration by Genetic Search"; Conf. Proc., IEEE Southeastcon 1984; pp. 460–464.

Foley, J. D., Wallace, V. L., Chan, P., "The Human Factor of Computer Graphics Interaction Techniques", IEEE CG&A, November 1984, pp. 13–48.

Friedman, M. B., "An Eye Gaze Controlled Keyboard", Proceedings of the 2nd International Conference on Rehabilitation Engineering, 1984, 446–447.

Fua, P. V., "Using probability density functions in the framework of evidential reasoning Uncertainty in knowledge based systems", B. Bouchon, R. R. Yager, Eds. Springer Verlag (1987).

Gilfoil, D., and Mauro, C. L., "Integrating Human Factors and Design: Matching Human Factors Methods up to Product Development", C. L. Mauro Assoc., Inc., 1–7.

Gleick, James, "Making a New Science", pp. 215, 239, date unknown.

Gogoussis et al.; Proc. SPIE Intl. Soc. Opt. Eng., November 1984, Cambridge, Mass.; pp. 121–127.

Gonzalez, Rafael C., "Digital Image Processing", Addison-Wesley, Reading, Mass. (1987).

Gould, John D., Boies, Stephen J., Meluson, Antonia, Rasammy, Marwan, and Vosburgh, Ann Marie, "Entry and Selection Methods For Specifying Dates". Human Factors, 32(2):199–214 (April 1989).

Green, Lee, "Thermo Tech: Here's a common sense guide to the new thinking thermostats", Popular Mechanics, October 1985, 155–159.

Grossberg, S., G. Carpenter, "A Massively Parallel Architecture for a Self-Organizing Neural Pattern Recognition Machine," Computer Vision, Graphics, and Image Processing (1987, 37, 54–115), pp. 252–315.

Grudin, Jonathan, "The Case Against User Interface Consistency", MCC Technical Report Number ACA-HI-002-89, January 1989.

Gullichsen, E., E. Chang, "Pattern Classification by Neural Network: An Experiment System for Icon Recognition," ICNN Proceeding on Neural Networks, March 1987, pp. IV-725-32.

Haruki, K. et al.; "Pattern Recognition of Handwritten Phonetic Japanese Alphabet Characters"; International Joint Conference on Neural Networks, Washington, D.C.; January 1990; pp. II–515 to II–518.

Harvey, Michael G., and Rothe, James T., "VideoCassette Recorders: Their Impact on Viewers and Advertisers", Journal of Advertising, 25:19–29 (December/January 1985).

Hawkins, William J., "Super Remotes", Popular Science, February 1989, 76–77.

Hayashi, Y., et al.; "Alphanumeric Character Recognition Using a Connectionist Model with the Pocket Algorithm"; Proceedings of the International Joint Conference on Neural Networks, Washington, D.C. Jun. 18–22; 1989; vol. 2, pp. 606–613.

Henke, Lucy L., and Donohue, Thomas R., "Functional Displacement of Traditional TV Viewing by VCR

Owners", Journal of Advertising Research, 29:18–24 (April–May 1989).

Hinton et al.; "Boltzmann Machines: Constraint Satisfaction Networks that Learn"; Tech. Report CMU-CS-85-119; Carnegie-Mellon Univ; 5/84.

Hirzinger, G., Landzettel, K., "Sensory Feedback Structures for Robots with Supervised Learning", IEEE Conf. on Robotics and Automation, St. Louis, March 1985.

Hoban, Phoebe, "Stacking the Decks", New York, Feb. 16, 1987, 20:14.

Hoffberg, Linda I., "AN IMPROVED HUMAN FACTORED INTERFACE FOR PROGRAMMABLE DEVICES: A CASE STUDY OF THE VCR", Master's Thesis, Tufts University (Master of Sciences in Engineering Design, November).

Hoffberg, Linda I., "Designing User Interface Guidelines For Time-Shift Programming of a Video Cassette Recorder (VCR)", Proc. of the Human Factors Soc. 35th Ann. Mtg. pp. 501–504 (1991).

Hoffberg, Linda I., "Designing a Programmable Interface for a Video Cassette Recorder (VCR) to Meet a User's Needs", Interface 91 pp. 346–351 (1991).

Hopfield et al; "Computing with Neural Circuits: A Model"; Science; vol. 233:625–633 (8 Aug. 1986).

Hopfield; "Neurons with graded response have collective computational properties like those of two-state neurons"; Proc. Natl. Acad. Sci. USA; 81:3088–3092 (May 1984).

Hopfield; "Neural Networks and Physical Systems with Emergent Collective Computational Abilities"; Proc. Natl. Acad. Sci. USA; 79:2554–2558 (April 1982).

Horgan, H., "Medical Electronics", IEEE Spectrum, January 1984, pp. 90–93.

Howard, Bill, "Point and Shoot Devices", PC Magazine, 6:95–97, August 1987.

Information Processing 71; North-Holland Publishing Company (1972) pp. 1530–1533.

Ishizuka, M., "Inference methods based on extended Dempster and Shafer's theory for problems with uncertainty/fuzziness", New Generation Computing, 1:159–168 (1983), Ohmsha, Ltd., and Springer Verlag.

Jackel, L. D., H. P. Graf, J. S. Denker, D. Henderson and I. Guyon, "An Application of Neural Net Chips: Handwritten Digit Recognition," ICNN Proceeding, 1988, pp. II-107-15.

Jane Pauley Special, NBC TV News Transcript, Jul. 17, 1990, 10:00 PM.

Jean, J. S. N., et al.; "Input Representation and Output Voting Considerations for Handwritten Numeral Recognition with Backpropagation"; International Joint Conference on Neural Networks, Washington, D.C., January 1990; pp. I–408 to I–411.

Jeffrey, R. J., "The logic of decision", The University of Chicago Press, Ltd., London (1983)(2nd Ed.).

Kaufmann, A., "Introduction a la theorie des sous-ensembles flous", Vol. 1, 2 et 3-Masson-Paris (1975).

Keeney, R. L., B. Raiffa, "Decisions with multiple objectives: Preferences and value tradeoffs", John Wiley and Sons, New York (1976).

Kellman, P., "Time Integrating Optical Signal Processing", Ph. D. Dissertation, Stanford University, 1979, pp. 51–55.

Kim, Y., "Chips Deliver Multimedia", Byte, December 1991, pp. 163–173.

Knowlton, K., "Virtual Pushbuttons as a Means of Person-Machine Interaction", Proc of Conf. Computer Graphics, Pattern Recognition and Data Structure, Beverly Hills, Calif., May 1975, pp. 350–352.

Koch, H., "Ergonomische Betrachtung von Schreibtastaturen", Humane Production, 1, pp. 12–15 (1985).

Kohonen; "Self-Organization & Memory", Second Ed., 1988; Springer-Verlag; pp. 199–209.

Kolson, Ann, "Computer wimps drown in a raging sea of technology", The Hartford Courant, May 24, 1989, B1.

Kortegaard, B. L.; "PAC-MAN, a Precision Alignment Control System for Multiple Laser Beams Self-Adaptive Through the Use of Noise"; Los Alamos National Laboratory; date unknown.

Kortegaard, B. L.; "Superfine Laser Position Control Using Statistically Enhanced Resolution in Real Time"; Los Alamos National Laboratory; SPIE-Los Angeles Technical Symposium; Jan. 23–25, 1985.

Kraiss, K. F., "Alternative Input Devices For Human Computer Interaction", Forschunginstitut Für Anthropotecahnik, Werthhoven, F. R. Germany.

Kraiss, K. F., "Neuere Methoden der Interaktion an der Schnittstelle Mensch-Maschine", Z. F. Arbeitswissenschaft, 2, pp. 65–70, 1978.

Kreifeldt, John, "Human Factors Approach to Medical Instrument Design", Electro/82 Proceedings, 3/3/1–3/3/6.

Kreifeldt, J. G., "A Methodology For Consumer Product Safety Analysis", The 3rd National Symposium on Human Factors in Industrial Design in Consumer Products, August 1982, 175–184.

Ksienski et al., "Low Frequency Approach to Target Identification", Proc. of the IEEE, 63(12):1651–1660 (December 1975).

Kuocheng, Andy Poing, and Ellingstad, Vernon S., "Touch Tablet and Touch Input", Interface '87, 327.

Kyburg, H. E., "Bayesian and non Bayesian evidential updating", Artificial Intelligence 31:271–293 (1987).

LeCun, Y., et al., "Handwritten Digit Recognition: Applications of Neural . . . ", IEEE Comm. Magazine, pp. 41–46 (November 1989).

LeCun, Y., "Connectionism in Perspective", in R. Pfeifer, Z. Schreter, F. Fogelman, L. Steels, (Eds.), 1989, "Generalization and Network Design Strategies", pp. 143–55.

Ledgard, Henry, Singer, Andrew, and Whiteside, John, Directions in Human Factors for Interactive Systems, New York, Springer-Verlag, 1981.

Lee, Eric, and MacGregor, James, "Minimizing User Search Time Menu Retrieval Systems", Human Factors, 27(2): 157–162 (April 1986).

Lendaris, G. G., and Stanely, G. L., "Diffraction Pattern Sampling for Automatic Target Recognition", Proc. IEEE 58:198–205 (1979).

Leon, Carol Boyd, "Selling Through the VCR", American Demographics, December 1987, 40–43.

Liepins, G. E., M. R. Hilliard; "Genetic Algorithms: Foundations & Applications"; Annals of Operations Research, 21:31–58 (1989).

Lin, H. K., et al.; "Real-Time Screen-Aided Multiple-Image Optical Holographic Matched-Filter Correlator"; Applied Optics; 21(18):3278–3286 (Sep. 15, 1982)

Lippmann, R. P., "An Introduction to Computing with Neural Nets", IEEE ASSP Magazine, 4(2):4–22 (April 1987).

Long, John, "The Effect of Display Format on the Direct Entry of Numerical Information by Pointing", Human Factors, 26(1):3–17 (February 1984).

Lu, C., "Computer Pointing Devices: Living With Mice", High Technology, January 1984, pp. 61–65.

Mahalanobis, A., et al.; "Minimum Average Correlation Energy Filters"; Applied Optics; 26(17):3633–40 (Sep. 1, 1987).

Mandelbrot, B., "The Fractal Geometry of Nature", W. H. Freeman & Co., San Francisco, Calif., 1982, 1977; and

Mantei, Marilyn M., and Teorey, Toby J., "Cost/Benefit Analysis for Incorporating Human Factors in the Software Lifecycle", Association for Computing Machinery, 1988.

Maragos, P., "Tutorial Advances in Morphological Image Processing" Optical Engineering 26:7:623–632 (1987).

Martin, G. L. et al.; "Recognizing Hand-Printed Letters and Digits Using Backpropagation Learning"; Technical Report of the MCC, Human Interface Laboratory, Austin, Tex.; January 1990; pp. 1–9.

McAulay, A. D., J. C. Oh; "Image Learning Classifier System Using Genetic Algorithms"; IEEE Proc. of the National Aerospace & Electronics Conference; 2:705–710 (1989).

Meads, Jon A., "Friendly or Frivolous", Datamation, Apr. 1, 1988, 98–100.

Miller, R. K.; Neural Networks ((c) 1989: Fairmont Press; Lilburn, Ga.); pp. 2–12 and Chapter 4, "Implementation of Neural Networks"; pp. 4-1 to 4-26.

Molley, P., "Implementing the Difference-Squared Error Algorithm Using An Acousto-Optic Processor", SPIE, 1098:232–239,(1989).

Molley, P., et al., "A High Dynamic Range Acousto-Optic Image Correlator for Real-Time Pattern Recognition", SPIE, 938:55–65 (1988).

Moore, T. G. and Dartnall, "Human Factors of a Microelectronic Product: The Central Heating Timer/Programmer", Applied Ergonomics, 13(1):15–23 (1983).

Mori; "Towards the construction of a large-scale neural network"; Electronics Information Communications Association Bulletin PRU 88-59; pp. 87–94.

Naik et al., "High Performance Speaker Verification . . . ", ICASSP 86, Tokyo, CH2243-4/86/0000-0881, IEEE 1986, pp. 881–884.

Netravali, Arun N., and Haskell, Barry G., "Digital Pictures Representation and Compression", Plenum Press, New York (1988).

Ney, H., et al.; "A Data Driven Organization of the Dynamic Programming Beam Search for Continuous Speech Recognition"; Proc. ICASSP 87; pp. 833–836; 1987.

Nilsson, N. J.; The Mathematical Foundations of Learning Machines ((c) 1990: Morgan Kaufmann Publishers, San Mateo, Calif.) and particularly section 2.6 "The Threshold Logic Unit (TLU)", pp. 21–23 and Chapter 6, "Layered Machines" pp. 95–114.

Norman, Donald A., "Infuriating By Design", Psychology Today, 22(3):52–56 (March 1988).

Norman, Donald A., The Psychology of Everyday Things, New York: Basic Book, Inc. 1988.

Norman, D. A., Fisher, D., "Why Alphabetic Keyboards Are Not Easy To Use: Keyboard Layout Doesn't Much Matter", Human Factors 24(5), pp. 509–519 (1982).

O'Neal et al.; "Coding Isotropic Images"; November 1977; pp. 697–707.

Ohsuga et al, "Entrainment of Two Coupled van der Pol Oscillators by an External Oscillation", Biological Cybernetics, 51:225–239 (1985).

Omata et al, "Holonic Model of Motion Perception", IEICE Technical Reports, 3/26188, pp. 339–346.

Optical Engineering 28:5 (May 1988)(Special Issue on product inspection).

Pawlicki, T. F., D. S. Lee, J. J. Hull and S. N. Srihari, "Neural Network Models and their Application to Handwritten Digit Recognition," ICNN Proceeding, 1988, pp. II-63-70.

Perry et al.; "Auto-Indexing Storage Device"; IBM Tech. Disc. Bulletin, 12(8):1219 (January 1970).

Perspectives: High Technology 2, 1985.

Peterson, Ivars, "Packing It In-Fractals . . . ", Science News, 131(18):283–285 (May 2, 1987).

Platte, Hans-Joachim, Oberjatzas, Gunter, and Voessing, Walter, "A New Intelligent Remote Control Unit for Consumer Electronic Device", IEEE Transactions on Consumer Electronics, Vol. CE-31(1):59–68 (February 1985).

Press, William H. et al, "Numerical Recipes in C The Art of Scientific Computing", Cambridge University Press, 1988.

Proakis, John G., *Digital Communications*, McGraw-Hill (1983)

Proceedings, 6th International Conference on Pattern Recognition 1982, pp. 152–136.

Psaltis, D., "Two-Dimensional Optical Processing Using One-Dimensional Input Devices", Proceedings of the IEEE, 72(7):962–974 (July 1984).

Psaltis, D., "Incoherent Electro-Optic Image Correlator", Optical Engineering, 23(1):12–15 (January/February 1984).

Ravichandran, G. and Casasent, D., "Noise and Discrimination Performance of the MINACE Optical Correlation Filter", Proc. SPIE Technical Symposium, April 1990, Orlando Fla., 1471 (1990).

Rhodes, W., "Acousto-Optic Signal Processing: Convolution and Correlation", Proc. of the IEEE, 69(1):65–79 (January 1981).

Richards J., and Casasent, D., "Real Time Hough Transform for Industrial Inspection" Proc. SPIE Technical Symposium, Boston 1989 1192:2–21 (1989).

Rogus, John G. and Armstrong, Richard, "Use of Human Engineering Standards in Design", Human Factors, 19(1): 15–23 (February 1977).

Rosch, Winn L., "Voice Recognition: Understanding the Master's Voice", PC Magazine, Oct. 27, 1987, 261–308.

Rosenfeld, Azriel and Avinash C. Kak; Digital Picture Processing, Second Edition, Volume 2, Academic Press, 1982.

Roy, B., "Classements et choix en presence de points de vue multiples", R.I.R.O.-2eme annee-no. 8; pp. 57–75 (1968).

Roy, B., "Electre III: un algorithme de classements fonde sur une representation floue des preferences en presence de criteres multiples" Cahiers du CERO, 20(1):3–24 (1978).

Rumelhart, D. E., et al.; Parallel Distributed Processing, ((c) 1986: MIT Press, Cambridge, Mass.), and specifically Chapter 8 thereof, "Learning Internal Representations by Error Propagation"; pp. 318–362.

Rumelhart, D. E., et al.; "Learning Internal Representations by Error Propagation"; Parallel Distr. Proc.: Explorations in Microstructure of Cognition, 1:318–362 (1986).

Rutherford, H. G., F. Taub and B. Williams; "Object Identification and Measurement from Images with Access to the Database to Select Specific Subpopulations of Special Interest"; May 1986.

Rutter et al.; "The Timed Lattice-A New Approach To Fast Converging Equalizer Design"; pp.VIII/1–5 (Inspec. Abstract No. 84C044315, Inspec IEE (London) & IEE Saraga Colloquium on Electronic Filters, May 21, 1984)

Sakoe, H.; "A Generalization of Dynamic Programming Based Pattern Matching Algorithm Stack DP-Matching"; Transactions of the Committee on Speech Research; The Acoustic Society of Japan; p. S83-23; 1983.

Sakoe, H.; "A Generalized Two-Level DP-Matching Algorithm for Continuous Speech Recognition"; Transactions of the IECE of Japan; E65(11):649–656 (November 1982).

Sarver, Carleton, "A Perfect Friendship", High Fidelity, 39:42–49 (May 1989).

Scharlic, A., "Decider sur plusieurs criteres. Panorama de l'aide a la decision multicritere" Presses Polytechniques Romandes (1985).

Schmitt, Lee, "Let's Discuss Programmable Controllers", Modern Machine Shop, May 1987, 90–99.

Schniederman, Ben, Designing the User Interface: Strategies for Effective Human-Computer Interaction, Reading, Mass., Addison-Wesley, 1987.

Schurmann, J.; "Zur Zeichen und Worterkennung beim Automatischen Anschriftenlesen"; Wissenschaftlichl, Berichte, 52(1/2) (1979).

Scientific American; "Not Just a Pretty Face"; March 1990, pp. 77–78.

Shafer, G., "A mathematical theory of evidence", Princeton University Press, Princeton, N.J. (1976).

Shimizu et al, "Principle of Holonic Computer and Holovision", Journal of the Institute of Electronics, Information and Communication, 70(9):921–930 (1987).

Shinan et al., "The Effects of Voice Disguise . . . ", ICASSP 86, Tokyo, CH2243-4/86/0000–0885, IEEE 1986, pp. 885–888.

Silverston et al.; "Spectral Feature Classification and Spatial Pattern Rec."; SPIE 201:17–26, Optical Pattern Recognition (1979).

Simpson, W. R., C. S. Dowling; "WRAPLE: The Weighted Repair Assistance Program Learning Extension"; IEEE Design & Test, 2:66–73 (April 1986).

Smith, Sidney J., and Mosier, Jane N., Guidelines for Designing User Interface Software, Bedford, Mass.; MITRE, 1986.

Specht; IEEE Internatl. Conf. Neural Networks, 1:I525–I532 (July 1988); San Diego, Calif.

Sperling, Barbara Bied, Tullis Thomas S., "Are You a Better 'Mouser' or 'Trackballer'? A Comparison of Cursor—Positioning Performance", An Interactive/Poster Session at the CHI+GI'87 Graphics Interface and Human Factors in Computing Systems Conference.

Sprageu, R. A.; "A Review of Acousto-Optic Signal Correlators"; Optical Engineering; 16(5):467–74 (September/October 1977)

Stanley R. Sternberg; "Biomedical Image Processing"; IEEE Computer; 1983; pp. 22–34.

Stewart, R. M.; "Expert Systems For Mechanical Fault Diagnosis"; IEEE; 1985; pp. 295–300.

Streeter, L. A., Ackroff, J. M., and Taylor, G. A. "On Abbreviating Command Names", The Bell System Technical Journal, 62(6):1807–1826 (July/August 1983).

Sugeno, M., "Theory of fuzzy integrals and its applications", Tokyo Institute of Technology (1974).

Svetkoff et al.; Hybrid Circuits (GB), No. 13, May 1987; pp. 5–8.

Swanson, David, and Klopfenstein, Bruce, "How to Forecast VCR Penetration", American Demographic, December 1987, 44–45.

Tello, Ernest R., "Between Man And Machine", Byte, September 1988, 288–293.

Thomas, John, C., and Schneider, Michael L., Human Factors in Computer Systems, New Jersey, Ablex Publ. Co., 1984.

Trachtenberg, Jeffrey A., "How do we confuse thee? Let us count the ways", Forbes, Mar. 21, 1988, 159–160.

Tyldesley, D. A., "Employing Usability Engineering in the Development of Office Products", The Computer Journal", 31(5):431–436 (1988).

Udagawa, K., et al; "A Parallel Two-Stage Decision Method for Statistical Character Recognition . . . "; Electronics and Communications in Japan (1965).

Vander Lugt, A., "Signal Detection By Complex Spatial Filtering", IEEE Transactions On Information Theory, IT-10, 2:139–145 (April 1964).

Vander Lugt, A., et al.; "The Use of Film Nonlinearites in Optical Spatial Filtering"; Applied Optics; 9(1):215–222 (January 1970).

Vander Lugt, A.; "Practical Considerations for the Use of Spatial Carrier-Frequency Filters"; Applied Optics; 5(11): 1760–1765 (November 1966).

Vannicola et al, "Applications of Knowledge based Systems to Surveillance", Proceedings of the 1988 IEEE National Radar Conference, 20–21 Apr. 1988, pp. 157–164.

Verplank, William L., "Graphics in Human-Computer Communication: Principles of Graphical User-Interface Design", Xerox Office Systems.

Vitols; "Hologram Memory for Storing Digital Data"; IBM Tech. Disc. Bulletin 8(11):1581–1583 (April 1966).

Voyt, Carlton F., "PLC's Learn New Languages", Design News, Jan. 2, 1989, 78.

Wald; Sequential Analysis; Dover Publications Inc., 1947; pp. 34–43.

Wasserman, Philip D.; "Neural Computing-Theory & Practice"; 1989; pp. 128–129.

Weshsler, H. Ed., "Neural Nets For Human and Machine Perception", Academic Press, New York (1991).

Whitefield, A. "Human Factors Aspects of Pointing as an Input Technique in Interactive Computer Systems", Applied Ergonomics, June 1986, 97–104.

Wiedenbeck, Susan, Lambert, Robin, and Scholtz, Jean, "Using Protocol Analysis to Study the User Interface", Bulletin of the American Society for Information Science, June/July 1989, 25–26.

Wilke, William, "Easy Operation of Instruments by Both Man and Machine", Electro/82 Proceedings, 3/2/1–3/2/4.

Willshaw et al.; "Non-Holographic Associative Memory"; Nature; 222:960–962 (Jun. 7, 1969).

Yager, R. R., "Entropy and specificity in a mathematical theory of Evidence", Int. J. General Systems, 9:249–260 (1983).

Yamada et. al.; "Character recognition system using a neural network"; Electronics Information Communications Association Bulletin PRU 88-58, pp. 79–86.

Yamane et al.; "An Image Data Compression Method Using Two-Dimensional Extrapolative Prediction-Discrete Sine Transform"; Oct. 29–31, 1986; pp. 311–316.

Yoder, Stephen Kreider, "U.S. Inventors Thrive at Electronics Show", The Wall Street Journal, Jan. 10, 1990, B1.

Zadeh, L. A., "Fuzzy sets", Information and Control, 8:338–353 (1965).

Zadeh, L. A., "Probability measures of fuzzy events", Journal of Mathematical Analysis and Applications, 23:421–427 (1968).

Zadeh, L. A., "Fuzzy sets as a basis for a theory of possibility", Fuzzy sets and Systems 1:3–28 (1978).

Zeisel, Gunter, Tomas, Philippe, Tomaszewski, Peter, "An Interactive Menu-Driven Remote Control Unit for TV-Receivers and VC-Recorders", IEEE Transactions on Consumer Electronics, 34(3):814–818.

Zhu, X., et al.; "Feature Detector and Application to Handwritten Character Recognition"; International Joint Conference on Neural Networks, Washington, D.C.; January 1990; pp. II-457 to II-460.

What is claimed is:

1. A human interface device for a user comprising:

a data transmission selector for selecting at least one of a plurality of simultaneously transmitted programs being responsive to an input;

a program database containing information relating to at least one said plurality of programs, having an output;

a graphical user interface for receiving user commands; and

a controller for controlling said graphical user interface and said data transmission selector, said controller determining a user characteristic based on implicit data, receiving said output of said program database and presenting, based on said user characteristic and said program database, information relating to at least one of said plurality of programs on said graphic user interface in association with a command, said graphic user interface allowing the user to select said command and thereby authorize an operation in relation to said at least one of said plurality of programs.

2. The interface device according to claim 1, further comprising:

a plurality of stored profiles;

a processor for characterizing input to said graphic user interface to produce a characterized user input; and

means for comparing said characterized user input with at least one of said stored profiles to produce a comparison index,

wherein said graphic user interface is modified on the basis of said comparison index.

3. The interface device according to claim 1, further comprising:

an image analyzer for analyzing at least one of said plurality of programs, and providing an analysis to said controller, said controller associating commands with said at least one of said plurality of programs based on said analysis.

4. The interface device according to claim 1, wherein said graphic user interface comprises:

(a) an image display device having at least two dimensions of display, providing visual image feedback to a user; and

(b) a multidimensional input device having at least one independent axis of operability, said axis corresponding to an axis of said display device, and having an output,

so that the user may cause said input device to produce a change in an image of said display device by translating a repositionable indicator portion of said display along said at least one axis of operability, based on said visual image feedback received from said image display device, said indicator portion being repositioned to a translated location of said display device corresponding to a user input.

5. The interface device according to claim 1, wherein said determined user characteristic relates indirectly to said received user commands.

6. An apparatus, receiving an input from a human user having a user characteristic, comprising:

an input device, producing an input signal from the human user input;

a display for displaying information relating to the input from the user and feedback on a current state of the apparatus, having an alterable image type;

an input processor for extracting an input instruction relating to a desired change in a state of the apparatus from the input signal;

a detector for detecting one or more temporal-spatial user characteristics of the input signal, independent of said input instruction, selected from the group consisting of a velocity component, an efficiency of input, an accuracy of input, an interruption of input and a high frequency component of input;

a memory for storing data related to said user characteristics; and

a controller for altering said image type based on the user characteristics.

7. The apparatus according to claim 6, wherein said controller alters said image type based on an output of said detector and said stored data so that said display displays an image type which corresponds to said detected user characteristics.

8. The apparatus according to claim 6, being for controlling the causation of an action on the occurrence of an event, further comprising:

a control for receiving said input instruction and storing a program instruction associated with said input instruction, said control having a memory sufficient for storing program instructions to perform an action on the occurrence of an event; and

a monitor for monitoring an environment of said apparatus to determine the occurrence of the event, and causing the performance of the action on the occurrence of the event.

9. The apparatus according to claim 8, wherein said controller alters said image type based on an output of said detector and said stored data so that said display means displays an image type which corresponds to said detected user characteristics.

10. A programmable device, comprising:

an input for receiving path dependant and path independent user data;

a filter, separating said path dependant user data as user characterization data and said path independent user data as instructions;

a memory for storing said user characterization data;

a processor for executing said instructions; and

a feedback device, presenting information relating to said instructions and said stored user characterization data.

11. The device according to claim 10, further comprising:

a hierarchical command structure of said processor, said command structure having commands of different function; and

means for predicting a probability of execution of a plurality of commands based on said input,

said feedback device presenting commands based on at least said predicted probabilities.

12. The device according to claim 10, further comprising:

an input for receiving environmental data;

a hierarchical command structure of said processor, said command structure having commands of different function; and

means for predicting a probability of execution of a plurality of commands based on said environmental data,

said feedback device presenting commands based on at least said predicted probabilities.

13. The device according to claim 12, wherein said environmental data comprises a plurality of audio or image data streams.

14. The device according to claim 13, wherein said processor selectively processes an audio or image stream.

15. The device according to claim 12, wherein said means for predicting comprises a pattern matching processor comparing environmental data patterns with stored data patterns.

16. The device according to claim **10**, wherein said path dependant user data is selected from the group consisting of a velocity component, an efficiency of input, an accuracy of input, an interruption of input and a high frequency component of input.

17. The device according to claim **10**, wherein said path independent user data comprises an input status.

18. The device according to claim **10**, wherein said input and said feedback device comprise a graphic user interface having at least two input axes.

19. The programmable device according to claim **10**, further comprising:

a display for displaying information relating to the input from the user and feedback on a current state of the apparatus, having an alterable image type;

said filter being an input processor, for separating said path independent data as an input instruction relating to a desired change in state of the apparatus; and

a detector for detecting one or more temporal-spatial user characteristics of the input signal as path dependent data, independent of said input instruction, selected from the group consisting of a velocity component, an efficiency of input, an accuracy of input, an interruption of input and a high frequency component of input,

said feedback device being responsive to said processor for altering an image type of said display based on said user characteristics.

20. The programmable device according to claim **10**, further comprising:

a data transmission selector for selecting at least one of a plurality of simultaneously transmitted programs being responsive to an input;

a program database containing information relating to at least one said plurality of programs, having an output;

a graphical user interface for receiving user commands, comprising said input and said feedback device; and

a controller, comprising said filter, said processor and said memory, for controlling said graphical user interface and said data transmission selector, said controller determining a user characteristic as said user characterization data, receiving said output of said program database and presenting, based on said user characteristic and said program database, information relating to at least one of said plurality of programs on said graphic user interface in association with a command, said graphic user interface allowing the user to select said command and thereby authorize an operation in relation to said at least one of said plurality of programs.

21. A human interface device for a user comprising:

a user interface for receiving user commands, having an image information display and a user input defining a spatial relationship with said information display;

a media data processor, adapted to selectively process at least one transmitted media program selected from the group consisting of a plurality of transmitted media programs, being responsive to a selection input;

a database containing information relating to a plurality of media programs, said information contained in said database being accessible through an interface system; and

a control system, for:

(a) controlling said user interface to present display information relating to a state of said control and receiving user input;

(b) controlling said media data processor to selectively process at least one transmitted program through said selection input;

(c) determining a user characteristic based on implicit data, having a relation to said information relating to a plurality of media programs stored in said database;

(d) processing said determined user characteristic and at least a portion of said information contained in said database, selectively and differentially processing information relating to at least one of said media programs;

(e) presenting to the user said selectively and differentially processed information relating to at least one of said media programs;

(f) receiving, from the user, a command, said command relating to a desired function of said media data processor.

22. The human interface device according to claim **21**, wherein said user characteristic is determined based on a temporal-spatial characteristic of said user input.

23. The interface device according to claim **21**, wherein said media data processor comprises a selector for selecting a transmitted media program.

24. The interface device according to claim **21**, wherein said media programs comprise video data streams.

25. The interface device according to claim **21**, wherein said selective and differential processing of information relating to at least one of said media programs comprises outputting a set of identifications of selected media programs.

26. The interface device according to claim **21**, wherein said selective and differential processing of information relating to at least two of said media programs to produce an output of a non-zero degree of correspondence of said at least two of said media programs with said determined user characteristic.

27. The interface device according to claim **21**, wherein said determined user characteristic relates indirectly to said received user commands.

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