Massachusetts Institute of Technology

The Media Laboratory United States Patents

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Media Lab U.S. Patents (listed by filing date)

Fiscal Year Filing Year	Title	Case Number	Inventor(s)	U.S. Patent Number
2006	**Mobile Wakeup Device**	11615T	Gauri Nanda	7,355,928
2005	**Method for Arbitrarily High Order Elimination of Pulse Errors in NMR and Coherent Control**	10743T	Kenneth R. Brown, Aram W. Harrow, Isaac L. Chuang	7,423,427
2004	**A Three Dimensional Tangible Interface for Interacting with Spatial-Temporal Data Using a Laser Scanner**	9771T	Benjamin Tarquinn Fielding Piper, Carlo Filippo Ratti, Hiroshi Ishii	7,181,363
	A Three Dimensional Tangible Interface for Interacting with Spatial-Temporal Data Using Infrared Light Sources and Infrared Detectors	10274T	Yao Wang, Assaf Biderman, Carlo Ratti, Benjamin Piper, Hiroshi Ishii	7,181,362
	Analog Continuous Time Statistical Processing	10040T	Benjamin Vigoda, Neil Gershenfeld	7,209,867
	Three-Dimensional Characterization Using a One-Dimensional Electrode Array	9960T	Ernest Post, John Strachan, Neil Gershenfeld	6,891,382
	Tuneable Wireless Tags Using Spatially Inhomogeneous Structures	8313T	Richard Fletcher, Neil Gershenfeld	7,221,275
	Measuring Element Number and Position Through Resonance Interactions	9867T	Richard Fletcher, Olufemi Omojola	7,216,805
	Templated Monolayer Polymerization and Replication	9840T	Joseph Jacobson, David Mosley, Kie-Moon Sung	7,311,943
2003	**Self-Powered Wireless Switch**	9320T	H. Winston Maue (Lear), Richard Meinzer (Lear), Joseph Paradiso, Mark Feldmeier	6,933,655
	Measurement of Protein Concentrations and Binding Energetics	9981T	Scott Manalis	7,387,889
	Manually Operated Switch For Enabling and Disabling an RFID Card	10109T	Ted Selker	6,863,220
	Wireless Monitoring and Identification Using Spatially Inhomogeneous Structures	8313T	Richard Fletcher, Neil Gershenfeld	6,693,540
	Tag Interrogation with Observable Response Signal	9940T	Joseph Paradiso, Hongshen Ma, Andrew Lippman	7,109,865
	Reconfigurable Image Surface Holograms	9705T	Wendy Plesniak, Michael Halle	6,927,886
	Hybrid Wireless Network for Data Collection and Distribution	9770T	Richard Fletcher, David Cavallo, Alex Pentland, Amir Hasson	7,327,705
2002	**Quantum Digital Signatures**	9308T	Isaac Chuang, Daniel Gottesman	7,246,240
	Socializing Remote Communication	9704T	Angela Chang, Benjamin Resner, Hiroshi Ishii, Bruce Blumberg, Brad Koerner, Xing Wang	6,940,493
	Methods and Apparatus for Manufacturing Electronic and Electromechanical Elements Devices by Thin-Film Deposition and Imaging	8407T	Saul Griffith, Joseph Jacobson, Scott Manalis	6,664,027
	Self-Powered Wireless Switch	9320T	H. Winston Maue (Lear), Richard Meinzer (Lear), Joseph Paradiso, Mark Feldmeier	6,700,310
	Printable Electronic Display	7646T	Christopher Turner, Joseph Jacobson, Barret Comiskey	6,480,182
	Direct, Externally Imposed Control of Polypeptides	9230T	Joseph Jacobson, Kimberly Hamad, John Schwartz, Shuguang Zhang	6,953,656
	Direct, Externally Imposed Control of Nucleic Acids	9231T	Joseph Jacobson, John Schwartz	6,953,659
2001	**Wireless Roadway Monitoring System**	9198T	Joseph Paradiso, Ara Knaian	6,662,099
	Platform for Item Sensing and Identification	8148T	Richard Fletcher, Neil Gershenfeld, Paul Yarin, Hiroshi Ishii	6,791,452
	Nonlinear Dynamic System for Spread Spectrum Code Acquisition	8646T	Benjamin Vigoda	6,724,805
	Transmissionless Pressure-control Valve	8090T	Jeremy Levitan, Neil Gershenfeld, Ernesto Blanco	6,460,557

Media Lab U.S. Patents (listed by filing date) continued

Fiscal Year Filing Year	Title	Case Number	Inventor(s)	U.S. Patent Number
2001 (continued)	**Flexible Electronic Circuitry and Method of Making Same**	8283T	Rehmi Post, Neil Gershenfeld	6,493,933
	Sensing and Display of Skin Conductivity	8599T	Jocelyn Scheirer, Rosalind Picard, Nancy Tilbury, Jonathan Farringdon	6,415,176
	Frequency-based Wireless Monitoring and Identification Using Spatially Inhomogeneous Structures	8313T	Richard Fletcher, Neil Gershenfeld	6,724,310
	High-density Data Storage Using Atomic Force Microscope	8634T	Emily Cooper, Hongjie Dai, Hongbin Fang, Scott Manalis, Kazuhiko Matsumoto, Calvin Quate	6,519,221
	High-Sensitivity Interferometric Accelerometer	8678T	Scott Manalis	6,473,187
	Wireless Monitoring and Identification Using Spatially Inhomogeneous Structures	8313T	Neil Gershenfeld, Richard Fletcher	6,472,987
2000	**Multi-Axis Tracking of Passive Resonant Structures**	8780T	Joseph Paradiso, Kai-yuh Hsiao	5,404,340
	Methods and Apparatus for Manufacturing Bioelectric Devices	8492T	Joseph Jacobson, Scott Manalis, Brent Ridley	6,815,218
	Wireless Monitoring of Temperature	8217T	Richard Fletcher, Neil Gershenfeld	6,208,253
	Fabrication of Finely Featured Devices by Liquid Embossing	8661T	Joseph Jacobson, Colin Bulthaup, Eric Wilhelm, Brian Hubert	6,517,995
	Rolling Toy with Motion Recording and Playback Capability	8367T	Philipp Frei	6,354,842
	Methods for Manufacturing Electronic and Electromechanical Elements and Devices by Thin-film Deposition and Imaging	8407T	Saul Griffith, Joseph Jacobson, Scott Manalis	6,348,295
	Management of Properties for Hyperlinked Video	8643T	Jonathan Dakss, Nuno Vasconcelos, Edmond Chalom, V. Michael Bove, Jr.	6,642,940
	Identification and Verification Using Complex, Three-Dimensional Structural Features	8375T	Neil Gershenfeld, Ravikanth Pappu, Joshua Smith	6,584,214
	Method and Apparatus for Touch-Activated Identification and Information Transfer	8334T	Benjamin Vigoda, Neil Gershenfeld	6,642,837
	High Density Mechanical Memory and Tuning Machine	8215T	Joseph Jacobson, Brian Hubert, Brent Ridley	6,587,408
1999	**Nanoparticle-Based Electrical, Chemical, and Mechanical Structures and Methods of Making Same**	8216T	Joseph Jacobson, Brian Hubert, Brent Ridley, Babak Nivi, Sawyer Fuller	6,294,401
	Parametric Audio System	8077T	Joseph Pompei	6,775,338
	Memory Structures and Methods of Making Same	8214T	Joseph Jacobson, Brian Hubert	6,072,716
	Dynamic Holographic Video with Haptic Interaction	8010T	Wendy Plesniak, Ravikanth Pappu, Stephen Benton	6,211,848
	Apparatus for Resolving Presence and Orientation within a Defined Space	7295T C2	Neil Gershenfeld, Joshua Smith	6,066,954
	Heterogeneous Display Elements and Methods for Their Fabrication	7690T	Joseph Jacobson, Hidekazu Yoshizawa	6,241,921
	Method and Apparatus for Determining Three-Dimensional Position, Orientation and Mass Distribution	7294T P2	Neil Gershenfeld, Joshua Smith	6,025,726
	Method and Apparatus for Characterizing Movement of a Mass within a Defined Space	7295T D2	Neil Gershenfeld, Joshua Smith	6,051,981
	Autostereoscopic Display System	8155T	Stephen Benton	6,351,280
	Nonemissive Displays and Piezoelectric Power Supplies Therefor	7514T C1	Joseph Jacobson, Barrett Comiskey	6,130,773
	Multiple Viewer Auto-Stereoscopic Display Systems	7746T	Paul Christie	6,593,957
	Apparatus and Methods for Reversible Imaging of Nonemissive Display Systems	7932T	Joseph Jacobson	6,291,925

Media Lab U.S. Patents (listed by filing date) continued

Fiscal Year Filing Year	Title	Case Number	Inventor(s)	U.S. Patent Number
1998	**Method and Apparatus for Automated, Context-Dependent Retrieval of Information**	7870TS	Bradley Rhodes, Thad Starner, Pattie Maes, Alex Pentland	6,236,768
	System and Method for Multicast Video-on-Demand Delivery System	7973T	Roger Kermode, Henry Holtzman	6,018,359
	Method and Apparatus for Data Hiding in Printed Images	7754T	Walter Bender, Daniel Gruhl	6,212,285
	Method and Apparatus for Multi-Bit Zoned Data Hiding in Printed Images	8049T	Walter Bender, Daniel Gruhl	6,411,392
	Electrically Active Resonant Structures for Wireless Monitoring and Control	7550T	Neil Gershenfeld, Richard Fletcher	6,025,725
	Method and Apparatus for Data Hiding in Images	7116T C1	Walter Bender, Norishige Morimoto, Daniel Gruhl	5,870,499
	Method and Apparatus for Transbody Transmission of Power and Information	7802T	Rehmi Post, Babak Nivi, Neil Gershenfeld	6,211,799
	Method of Fabricating Electro-Mechanical Devices by Multilayer Deposition	7457T	Joseph Jacobson, Jonathan Albert, Neil Gershenfeld	6,200,508
	Method for Resolving Presence, Orientation and Activity in a Defined Space	7295T C1	Neil Gershenfeld, Joshua Smith	5,936,412
	Electrically Active Textiles and Articles Made Therefrom	7813T	Rehmi Post, Margaret Orth, Emily Cooper, Joshua Smith	6,210,771
	Digital Communication, Programmable Functioning and Data Transfer Using Modular, Hinged Processor Elements	7700T	Matthew Gorbet, Margaret Orth	5,941,714
	Method of Creating a High Resolution Still Image Using a Plurality of Images and Apparatus for Practice of the Method	5717T CIP1C1	Walter Bender, Laura Teodosio	5,920,657
	Non-Contact System for Sensing and Signalling by Externally Induced Intra-Body Currents	6788T C1	Neil Gershenfeld, Thomas Zimmerman, David Allport	5,914,701
	Self-Organizing Network	7552T	Robert Poor	6,028,857
	Rear View Mirror with Integrated Matrix Display	8322T	Stephen Buckley, Betty Lou McClanahan	6,106,121
1997	**Method and Apparatus for Producing Binaural Audio for a Moving Listener**	7633T	William Gardner	6,243,476
	Apparatus and Method for Characterizing Movement of a Mass within a Defined Space	7295T D1	Neil Gershenfeld, Joshua Smith	5,914,610
	Printable Electronic Display	7646T	Christopher Turner, Joseph M. Jacobson, Barrett Comiskey	6,980,196
	Microencapsulated Electrophoretic Display	7645T	Joseph Jacobson, Barrett Comiskey, Jonathan Albert	5,961,804
	Apparatus for Controlling Continuous Behavior through Hand and Arm Gestures	7566T	Teresa Marrin, Joseph Paradiso, Tod Machover, Christopher Verplaetse, Margaret Orth	5,875,257
	Efficient Synthesis of Complex, Driven Systems	7523T	Neil Gershenfeld, Bernd Schoner, Eric Metois	6,000,833
	Nonemissive Displays and Piezoelectric Power Supplies Therefor	7514T	Joseph Jacobson, Barrett Comiskey	5,930,026
	Method and Apparatus for Quantum Information Processing	7490T	Neil Gershenfeld, Isaac Chuang	5,917,322
	Program-listing Appendix	7333TS	Henry Lieberman	6,353,822
	System Employing Dissipative Pseudorandom Dynamics for Communication and Measurement	6781T D1	Neil Gershenfeld	5,729,388
1996	**Method and Apparatus for Automatic Alignment of Volumetric Images Containing Common Subject Matter**	7118T	V. Michael Bove, Jr., Tamas Sandor	5,946,425
	Method and Apparatus for Echo Data Hiding in Audio Signals	7115T	Walter Bender, Daniel Gruhl, Norishige Morimoto	5,893,067

Media Lab U.S. Patents (listed by filing date) continued

Fiscal Year Filing Year	Title	Case Number	Inventor(s)	U.S. Patent Number
1996 (continued)	**Method and Apparatus for Producing Digital Images Having Extended Dynamic Ranges**	7347T	Steve Mann	5,828,793
	Method for Three-Dimensional Positions, Orientation and Mass Distribution	7294T CIP1	Neil Gershenfeld, Joshua Smith	5,844,415
	Bistable, Thermochromic Recording Method for Rendering Color and Gray Scale	7296T	Joseph Jacobson, V. Michael Bove, Jr.	6,022,648
	Method and Apparatus for Data Hiding in Images	7116T	Walter Bender, Norishige Morimoto, Daniel Gruhl	5,689,587
	Method and Apparatus for Logo Hiding in Images	7117T	Walter Bender, Norishige Morimoto, Daniel Gruhl	6,201,879
	Method and Apparatus for Relating and Combining Multiple Images of the Same Scene or Object(s)	7113T	Steve Mann, Rosalind Picard	5,706,416
1995	**System Employing Dissipative Pseudorandom Dynamics for Communications and Measurement**	6781T	Neil Gershenfeld	5,612,973
	Layered Representation for Image Coding	5763T	Edward Adelson	5,706,417
	Detection, Recognition and Coding of Complex Objects Using Probabilistic Eigenspace Analysis	6567T	Baback Moghaddam, Alex Pentland	5,710,833
	Method and System for Facilitating Wireless, Full-Body, Real-Time User Interaction with a Digitally Represented Visual Environment	6773T	Pattie Maes, Bruce Blumberg, Trevor Darrell, Thad Starner, Michael Johnson, Kenneth Russell, Alex Pentland	5,563,988
1994	**Method and Apparatus for Three-Dimensional, Textured Models from Plural Video Images**	6499T	Ali Azarbayejani, Tinsley Galyean, Alex Pentland	5,511,153
1993	**System for Encoding Image Data into Multiple Layers Representing Regions of Coherent Motion and Associated Motion Parameters**	6262T	John Wang, Edward Adelson	5,557,684
	Method of Creating a High Resolution Still Image Using a Plurality of Images and Apparatus for Practice of the Method	5717T	Walter Bender, Laura Teodosio	5,657,402
	Computer Method and Apparatus for Matching between Line Drawings	5831T	Tomaso Poggio, Stephen Librande	5,325,475
	Fractal-Based Image Compression and Interpolation	5189T	Alex Pentland, Eero Simoncelli, Thomas Stephenson	5,148,497
	Method and Apparatus for Electromagnetic Non-Contact Position Measurement with Respect to One or More Axes	5677T	Neil Gershenfeld	5,247,261
	Noise Reduction System	5684T	Edward Adelson, William Freeman	5,526,446
	Antialiasing Apparatus and Method for Computer Printers	5651T	V. Michael Bove, Jr., Christopher Mayer	5,185,852
	Automobile Navigation System Using Real Time Spoken Driving Instructions	5088TS	James Davis, Christopher Schmandt	5,177,685
	Method and Facility for Dynamic Video Composition and Viewing	5170T	Glorianna Davenport, Hans Brondmo	5,101,364
	Multiscale Coding of Images	4789T	Andrew Lippman, William Butera	4,987,480

Media Lab U.S. Patents Transferred to Public Domain (listed by filing date)

Fiscal Year Filing Year	Title	Case Number	Inventor(s)	U.S. Patent Number
1993	**Finite-Element Method for Image Alignment and Morphing**	6160T	Stanley Sclaroff, Alex Pentland	5,590,261
1992	**Video Image Compositing Techniques**	5529T	Andrew Lippman, Walter Bender, Patrick McLean, Henry Holtzman	5,262,856
1991	**Face Recognition System**	5404T	Matthew Turk, Alex Pentland	5,164,992
	Optical Ranging Apparatus	5222T	Edward Adelson	5,076,687
	Method for Estimating Solutions to Finite Element Equations by Generating Pyramid Representations, Multiplying to Generate Weight Pyramids, and Collapsing the Weighted Pyramids	5349T	Alex Pentland	5,287,529
1990	**Three-Dimensional Display System**	4942T	Stephen Benton, Joel Kollin	5,172,251
	Multidimensional Range Mapping with Pattern Project and Cross Correlation	5025T	Bernd Girod, Edward Adelson	5,003,166
	System for Ascertaining Direction of Blur in a Range-from-Defocus Camera	5025T	Bernd Girod, Edward Adelson	4,965,442
	Holographic Color Control Systems	5040T	Julie Walker, Stephen Benton	4,986,619
	Method and Apparatus for Image Processing to Obtain Three-Dimensional Motion and Depth	5156TS	David Heeger, Allan Jepson	4,980,762
	Self-Contained Compact Multi-Color Edge-Lit Holographic Display	4901T	Stephen Benton, Sabrina Birner	5,121,229
	Video-Graphic Arthroscopy System	4730T	Ernesto Blanco, Pascal Chesnais, Phyllis Kristal, Andrew Lippman	5,005,559
1989	**Receiver-Compatible Enhanced Definition Television System**	4851T	William Schreiber, Andrew Lippman, Edward Adelson, Aran Netravali	5,010,405
	Extended Definition Television System	4906T	Andrew Lippman, Edward Adelson, William Butera	5,003,377
1988	**Real Image Holographic Stereograms**	4509T	Andrew Lippman, V. Michael Bove, Jr., Jerome Wiesner	4,834,476
1984	**Unrecordable Video Signals**	3858T	Stephen Benton	4,673,981

Media Lab U.S. Patents
(listed by filing date)

Mobile Wakeup Device

Filing Date August 11, 2005
MIT Case Number 11615T
U.S. Patent Number 7,355,928
Issue Date April 8, 2008

Inventor Gauri Nanda

A mobile wake-up device responds to a snooze-button in an alarm clock. The mobile wakeup device includes a mechanism for making the device mobile, a controller for directing the movement of the device and responding to input, and an alarm off input. When the alarm clock's alarm goes off and an individual activates the snooze button, the mobile wake-up device moves forward, drops from a table to the floor, and moves to a remote location. While moving, the device may use sensors to avoid objects in its path. After the mobile wake-up device has reached the remote location, the alarm signals again. To turn off the alarm, the individual must get out of bed and locate the mobile wake-up device.

Method for Arbitrarily High Order Elimination of Pulse Errors in NMR and Coherent Control

Filing Date May 16, 2005
MIT Case Number 10743T
U.S. Patent Number 7,423,427
Issue Date September 9, 2008

Inventors Kenneth R. Brown, Aram W. Harrow, Isaac L. Chuang

The present invention is a method for constructing fully-compensating composite pulses of arbitrary accuracy that can correct pulse power errors to any desired order. The invention has two preferred embodiments, the Trotter-Suzuki (TS) embodiment and the Solovay-Kitaev (SK) embodiment. Each preferred embodiment can be represented by a mathematical algorithm, which can be easily implemented on a computer, for constructing a list of phases {.phi..sub.1, . . . , .phi..sub.l} and rotation angles {.theta..sub.1, . . . , .theta..sub.l} that amounts to a composite pulse. The pulses can then be used for nuclear magnetic resonance, quantum computing, or any other application based on pulsed excitations. The present invention, as embodied in the pulse sequences SK n and TS n, allows the user to transform a pulse sequence of error .epsilon. to a robust pulse sequence with error O(.epsilon..sup.n) for arbitrary n. The sequences can be implemented using any existing quantum computer or NMR hardware.

A Three Dimensional Tangible Interface for Interacting with Spatial-Temporal Data Using a Laser Scanner

Filing Date April 16, 2004
MIT Case Number 9771T
U.S. Patent Number 7,181,363
Issue Date February 20, 2007

Inventors Benjamin Tarquinn Fielding Piper, Carlo Filippo Ratti, Hiroshi Ishii

The Illuminated Workbench is a novel approach to human computer interaction. Users of the system can alter the geometry of a given physical form (such as a clay model representing a landscape topography). This dynamically changing geometry is captured in real-time by a 3d capture device (such as a 3d laser scanner). This geometric data serves as the input to the computational system and is analyzed in real time. The graphical results of this analysis are projected back onto the surface of the initial physical form. The output analysis results are precisely registered with the physical input geometry.

A Three Dimensional Tangible Interface for Interacting with Spatial-Temporal Data Using Infrared Light Sources and Infrared Detectors

Filing Date April 16, 2004
MIT Case Number 10274T
U.S. Patent Number 7,181,362
Issue Date February 20, 2007

Inventors Yao Wang, Assaf Biderman, Carlo Ratti, Benjamin Piper, Hiroshi Ishii

An interface that allows a user to model and analyze the properties of three dimensional surface and the regions surrounding such surfaces. The user manipulates a deformable bed of translucent glass beads that defines the geometry of a surface. An array of light emitting diodes underneath the beads transmits infrared light upwardly through the beads such that the intensity of radiation from each position on the surface of the beads is related to the depth of the beads at that position. A digital camera captures radiation image data which is then processed to create elevation data specifying the geometry of the surface. A processor processes the elevation data using a selected analysis function to produce result data representing computed characteristics of the surface or its surrounding region. The result data is projected as an image onto the surface of the beads. The interface permits the user to modify a surface geometry and directly visualize the characteristics of the modified geometry in real time.

Analog Continuous Time Statistical Processing

Filing Date 10/15/2003
MIT Case Number 10040T
U.S. Patent Number 7,209,867
Issue Date April 24, 2007

Inventors Benjamin Vigoda, Neil Gershenfeld

Methods and apparatus for applications such as signal processing, analysis, and coding/decoding replace digital signal processing elements with analog components. By combining soft logic gates and filters, the functionality of complex finite state machines can be implemented.

Three-Dimensional Characterization Using a One-Dimensional Electrode Array

Filing Date October 14, 2003
MIT Case Number 9960T
U.S. Patent Number 6,891,382
Issue Date May 10, 2005

Inventors Ernest Post, John Strachan, Neil Gershenfeld

A method is described to sense user interaction with a two-dimensional manifold, i.e., a flat or curved surface. The sensing surface incorporates a conformal resistive medium to guide electric fields in a preferred manner. These electric fields arise in response to boundary conditions imposed by connections to the sensing instrumentation. The boundary conditions are chosen to project measurement of current sources/sinks (e.g., the user's finger) onto observables of the circuit comprising the resistive manifold and the variable distribution of impendances arising from, user interaction. By projecting the 2D impedance distribution onto observables of the maifold's 1D boundary curve(s) the dimensionality of measurement (and its associated cost and complexity) are likewise reduced. The original 2D impedance distribution may then be reconstrcuted to an arbitrary degree, determined by the number of boundary measurements.

Tuneable Wireless Tags Using Spatially Inhomogeneous Structures

Filing Date September 3, 2003
MIT Case Number 8313T
U.S. Patent Number 7,221,275
Issue Date May 22, 2007

Inventors Richard Fletcher, Neil Gershenfeld

Tags encode information by means of spatial inhomogeneities that may be detected in the time domain; in effect, characteristics in space are transformed into time for sensing purposes. Such tags may be very inexpensively produced yet carry appreciable quantities of data. The inhomogeneities may be obtained by simple physical modifications to, or externally applied field biases operating on, materials that are very inexpensive to procure.

Measuring Element Number and Position Through Resonance Interactions

Filing Date 7/23/2003
MIT Case Number 9867T
U.S. Patent Number 7,216,805
Issue Date 5/15/2007

Inventors Richard Fletcher, Olufemi Omojola

Methods and apparatus for counting or measuring the relative positions of a number of resonant tag elements in proximity to each other. By measuring the resonant frequency of a given set of tags using a reader antenna and comparing the measured frequency to a reference resonant frequency, the observed frequency shift is used to ascertain certain properties of the set of tags, such as the number of tags present or the relative positions thereof.

Templated Monolayer Polymerization and Replication

Filing Date 7/17/2003
MIT Case Number 9840T
U.S. Patent Number 7,311,943
Issue Date 12/25/2007

Inventors Joseph Jacobson, David Mosley, Kie-Moon Sung

This invention generally relates to solution-based molecular shuttle devices. More particularly, this invention relates to solution-based molecular switches, molecular assemblies, and molecular memory devices and methods for producing the same. In some embodiments the devices are made from molecular chains constructed from molecular subunits which define binding positions and shuttles that are capable of moving along the chains.

Self-Powered Wireless Switch

Filing Date March 14, 2003
MIT Case Number 9320T
U.S. Patent Number 6,933,655
Issue Date August 23, 2005

Inventors H. Winston Maue (Lear), Richard Meinzer (Lear), Joseph Paradiso, Mark Feldmeier

A wireless switch is provided having a twenty-year life energy harvesting arrangement for self-powering a wireless transmitter. The energy harvesting arrangement is implemented in one embodiment using a piezoelectric switch element. A tritium light source and photovoltaic device are used in a second embodiment, while a black light source and photovoltaic device are used in a third embodiment. The energy harvesting wireless switch arrangement of the present invention can be combined, for example, with a vehicle side mirror switch, to reduce the complexity of the wire harness feeding the door. The wireless switch can be located without regard to accessability of a wiring harness or connector.

Measurement of Protein Concentrations and Binding Energetics

Filing Date January 2, 2003
MIT Case Number 9981T
U.S. Patent Number 7,387,889
Issue Date 6/17/2008

Inventor Scott Manalis

Free-standing microfluidic channels are used to both transport and analyze molecules of interest. In a biochemical context, such molecules may be polypeptides, nucleic acids, or other biomolecules. The free-standing channels provide a real-time readout of concentration without the need for labeling with reporter molecules. The channels can also measure enthalpy values and equilibrium constants by detecting heat released from or absorbed by the sample.

Manually Operated Switch For Enabling and Disabling an RFID Card

Filing Date December 31, 2002
MIT Case Number 10109T
U.S. Patent Number 6,863,220
Issue Date March 8, 2005

Inventor Ted Selker

A radio operated data card whose outer jacket forms a sealed protected housing for internal electrical components, including an RFID integrated circuit which incorporates data storage and a radio frequency transceiver, an on card antenna, and manually operated, normally open electrical switch contacts connected between the on-card electronic circuitry and the antenna. The open switch contacts normally disable the card, protecting the data on the card from being surreptitiously read until the switch contacts are intentionally closed by the cardholder,

to enable data transfer to occur. The cardholder may activate the card by applying external pressure to the surface of the card at a predetermined position, closing the switch contacts which open again automatically when pressure is removed. A tactile indicia on the surface of the card allows the cardholder to determine by touch where the card should be pressed to enable data transfers to occur. In an alternate embodiment, a mating key in the possession of the cardholder may be brought into proximity with the card to close the normally open switch to permit information to be read from the card.

Wireless Monitoring and Identification Using Spatially Inhomogenous Structures

Filing Date October 16, 2002
MIT Case Number 8313T
U.S. Patent Number 6,93,540
Issue Date February 17, 2004

Inventors Richard Fletcher, Neil Gershenfeld

Tags encode information by means of spatial inhomogeneities that may be detected in the time domain; in effect, characteristics in space are transformed into time for sensing purposes. Such tags may be very inexpensively produced yet carry appreciable quantities of data. The inhomogeneities may be obtained by simple physical modifications to, or externally applied field biases operating on, materials that are very inexpensive to procure.

Tag Interrogation with Observable Response Signal

Filing Date September 26, 2002
MIT Case Number 9940T
U.S. Patent Number 7,109,865
Issue Date September 15, 2006

Inventors Joseph Paradiso, Hongshen Ma, Andrew Lippman

An identification tag identifies a unique item from among a plurality of items with a similar appearance. Tagged items are searched by scanning the items with an interrogation signal. The tag emits an observable signal to indicate when it receives an identification that matches the identification contained in the tag. When the reader's interrogation is not present, the tag either sleeps at a very low power level or is passively unpowered.

Reconfigurable Image Surface Holograms

Filing Date August 2, 2002
MIT Case Number 9705T
U.S. Patent Number 6,927,886
Issue Date August 9, 2005

Inventors Wendy Plesniak, Michael Halle

The invention provides systems and methods for generating and displaying computational holographic stereograms having a hologram surface and a spatially distinct image surface. A three-dimensional object or scene is captured or synthesized as a stack of views. The holographic stereogram is computed by obtaining a diffractive fringe vector e and a pixel slice v through the stack of views, and generating the holopixel representation f = ev. The holographic stereogram is displayed using one or more image surfaces that are spatially distinct from the hologram surface. The surfaces can be any two-dimensional structures defined on a three-dimensional space, including, but not limited to planar, cylindrical, spherical, or other surfaces. The holographic stereograms are adjustable through variations in an image surface depth, an image surface resolution, a number of image surfaces, and a scene parallax resolution.

Hybrid Wireless Network for Data Collection and Distribution

Filing Date July 3, 2002
MIT Case Number 9770T
U.S. Patent Number 7,327,705
Issue Date February 5, 2008

Inventors Richard Fletcher, David Cavallo, Alex Pentland, Amir Hasson

An electronic data transport system includes a mobile access point and a carrier for moving the mobile access point over a surface and/or water route. The mobile access point includes a communications module for wirelessly transmitting data to and receiving data from one or more client devices when the client device is in proximity to the mobile access point.

Quantum Digital Signatures

Filing Date April 26, 2002
MIT Case Number 9308T
U.S. Patent Number 7,246,240
Issue Date July 17, 2007

Inventors Isaac Chuang, Daniel Gottesman

Systems and methods for providing secure quantum digital signatures. In one embodiment, a digital signature user creates a plurality of identical "public" keys having one or more bits and a corresponding quantum mechanical one-way function. Quantum digital signature recipients use a "swap test" to check the validity of a copy of the key, and compare the test results with others. The quantum digital signature user sends a signed message over any channel, including an insecure channel. The recipients evaluate the signed message, and quantify the number of incorrect keys. The message is deemed valid and original, or forged and/ or tampered with, when the number of incorrect keys is less than a lower threshold, or exceeds an upper threshold, respectively. For an intermediate number of incorrect keys, the recipients determine message authenticity by comparing observations. Hardware useful for application of the method is disclosed.

Socializing Remote Communication

Filing Date March 29, 2002
MIT Case Number 9704T
U.S. Patent Number 6,940,493
Issue Date September 6, 2005

Inventors Angela Chang, Benjamin Resner, Hiroshi Ishii, Bruce Blumberg, Brad Koerner, Xing Wang

Remote, non-verbal interpersonal communication is facilitated between communication stations located remotely from each other. A first communication station registers proximity of a user thereto and communicates to a second communication station a signal indicative of the registered proximity. The first communication station also registers a physical gesture and communicates a signal indicative of the gesture to the second communication station. The second communication station, in turn, receives the signals and, in response thereto, produces a visual output indicative of proximity and of the gestural input.

Methods and Apparatus for Manufacturing Electronic and Electromechanical Elements Devices by Thin-Film Deposition and Imaging

Filing Date January 30, 2002
MIT Case Number 8407T
U.S. Patent Number 6,664,027
Issue Date December 16, 2003

Inventors Saul Griffith, Joseph Jacobson, Scott Manalis

Electrically (and, possibly, mechanically) active patterns are applied using a colloidal suspension of nanoparticles that exhibit a desired electrical characteristic. The nanoparticles are surrounded by an insulative shells that may be removed by therefrom by application of energy (e.g., in the form of electromagnetic radiation or heat). The nanoparticle suspension is applied to a surface, forming a layer that is substantially insulative owing to the nanoparticle shells. The applied suspension is exposed to energy to remove the capping groups and fuse the particles into cohesion. If the nanoparticle suspension was deposited as a uniform film, the energy is applied in a desired pattern so that unexposed areas remain insulative while exposed areas exhibit the electrical behavior

associated with the nanoparticles. If the nanoparticle suspension was deposited in a desired pattern, it may be uniformly exposed to energy. Additional layers may be applied in the same manner, one over the other, to form a multilayer device.

Self-Powered Wireless Switch

Filing Date September 7, 2001
MIT Case Number 9320T
U.S. Patent Number 6,700,310
Issue Date March 2, 2004

Inventors H. Winston Maue (Lear), Richard Meinzer (Lear), Joseph Paradiso, Mark Feldmeier

A wireless switch is provided having a twenty-year life energy harvesting arrangement for self-powering a wireless transmitter. The energy harvesting arrangement is implemented in one embodiment using a piezoelectric switch element. A tritium light source and photovoltaic device are used in a second embodiment, while a black light source and photovoltaic device are used in a third embodiment. The energy harvesting wireless switch arrangement of the present invention can be combined, for example, with a vehicle side mirror switch, to reduce the complexity of the wire harness feeding the door. The wireless switch can be located without regard to accessability of a wiring harness or connector.

Printable Electronic Display

Filing Date July 20, 2001
MIT Case Number 8646T
U.S. Patent Number 6,480,182
Issue Date November 12, 2002

Inventors Christopher Turner, Joseph Jacobson, Barrett Comiskey

A display system includes a substrate upon which the display system is fabricated; a printable electrooptic display material, such as a microencapsulated electrophoretic suspension; electrodes (typically based on a transparent, conductive ink) arranged in an intersecting pattern to allow specific elements or regions of the display material to be addressed; insulating layers, as necessary, deposited by printing; and an array of nonlinear elements that facilitate matrix addressing. The nonlinear devices may include printed, particulate Schottky diodes, particulate PN diodes, particulate varistor material, silicon films formed by chemical reduction, or polymer semiconductor films. All elements of the display system may be deposited using a printing process.

Direct, Externally Imposed Control of Polypeptides

Filing Date July 13, 2001
MIT Case Number 9230T
U.S. Patent Number 6,953,656
Issue Date October 11, 2005

Inventors Joseph Jacobson, Kimberly Hamad, John Schwartz, Shuguang Zhang

Methods and compositions for rendering proteins directly responsive to an external signal utilizing modulators that themselves respond to the external signal and are associated with the proteins. In response to the external signal, the modulator alters physical properties of the specific protein molecule(s) with which it is associated, thereby altering the structural and functional properties thereof. The modulator may, for example, transfer applied energy to a protein, or to a portion of the protein, thereby changing the protein structure and function.

Direct, Externally Imposed Control of Nucleic Acids

Filing Date July 13, 2001
MIT Case Number 9231T
U.S. Patent Number 6,953,659
Issue Date October 11, 2005

Inventors Joseph Jacobson, John Schwartz

Methods and compositions for rendering necleic acids directly responsive to an external signal utilizing modulators that themselves respond to the external signal and are associated with the nucleic acid. In response to the external signal, the modulator alters physical properties of the specific nucleic acid molecule(s) with which it is associated, thereby altering the structural and funtional properties thereof. The modulator may, for example, transfer applied energy to a nucleic acid, or to a portion of the nucleic acid, thereby changing the nucleic acid structure.

Wireless Roadway Monitoring System

Filing Date May 22, 2001
MIT Case Number 9198T
U.S. Patent Number 6,662,099
Issue Date October 8, 2002

Inventors Joseph Paradiso, Ara Knaian

A wireless, in-road traffic sensor system using sensors that are small, low-cost, and rugged. The sensors may be capable of measuring the speed of passing vehicles, identifying the type of passing vehicle and measuring information about roadway conditions, e.g., wet or icy. The sensor includes a wireless transmitter and may be configured for installation beneath a roadway surface. The sensors may be configured as a traffic sensor system including distributed sensors across a roadway system, concentrators for receiving the sensor broadcasts and a central computer for accumulating and organizing the sensed information. The sensed information may also be made available responsive to user requests via the Web through such reports as traffic delays, alternate route planning and travel time estimates. Alternatively, the sensed information may also be used to control traffic through a traffic control means, such as a traffic signal.

Platform for Item Sensing and Identification

Filing Date December 27, 2000
MIT Case Number 8148T
U.S. Patent Number 6,791,452
Issue Date September 14, 2004

Inventors Richard Fletcher, Neil Gershenfeld, Paul Yarin, Hiroshi Ishii

The response of an object to a single time-varying magnetic field is sensed to determine object position and/or manipulation on a horizontal or vertical surface. A time-varying interrogation signal, which interacts with tags disposed on the surface, is read by an array of sensing coils. Control circuitry receives signals from the sensing coils representing this interaction and, based thereon, determines the identity, position, and manipulation of each of the objects based on the sensed signals and the known positions of the sensing coils. Feedback to the user can be provided in the form of a localized output (e.g. light, sound, heat, etc.) physically coincident with the object.

Nonlinear Dynamic System for Spread Spectrum Code Acquisition

Filing Date November 15, 2000
MIT Case Number 8646T
U.S. Patent Number 6,724,805
Issue Date April 20, 2004

Inventor Benjamin Vigoda

Nonlinear dynamic systems for generating and acquiring a spread spectrum signal pseudo-random noise (PN) signal are disclosed. An actuating signal is delayed by a first and second period to produce delayed actuating signals. A continuous, nonlinear function is applied to input that corresponds to the delayed actuating signals to produce an output signal. The function has values that correspond to the binary integer values of the mod 2 addition function of a linear feedback shift register, and a non-zero slope at those values. The output signal becomes a PN signal over time when it is fed back to the actuating signal. The output signal synchronizes with a

spread spectrum reference input signal when it is superposed on the reference input signal to produce the actuating signal. The system may be incorporated into a transmitter or a receiver, either of which may be part of a larger communication system.

Transmissionless Pressure-control Valve

Filing Date October 27, 2000
MIT Case Number 8090T
U.S. Patent Number 6,460,557
Issue Date October 8, 2002

Inventors Jeremy Levitan, Neil Gershenfeld, Ernesto Blanco

In a hydraulic or pneumatic flow-control valve, the valve stem itself is made a part of a solenoid arrangement that effects its reciprocation. The valve stem is magnetically responsive (e.g., magnetically permeable or ferromagnetic), and a magnetic field is applied to the stem to cause it to move within the bore of the valve housing; there is no external element required to urge the valve stem into movement. The valve stem is typically sealed permanently within the bore.

Flexible Electronic Circuitry and Method of Making Same

Filing Date October 18,2000
MIT Case Number 8283T
U.S. Patent Number 6,493,933
Issue Date December 17, 2002

Inventors Rehmi Post, Neil Gershenfeld

Stitchable electrical components have flexible, conductive leads and are encased, at least partially, in sealed packages. Conductive threads, yarns, or fiber bundles are patterned onto a flexible substrate (e.g., a textile panel). To form a circuit, the component leads are conductively stitched, spot welded, or otherwise joined to a textile panel so as to form connections between at least some of the stitched leads so as to form an electrical circuit. Alternatively, leads stitched into or otherwise joined to a textile pattern may be welded or otherwise permanently joined to flexible or non-flexible component leads to form a circuit. Multiple panels of circuitry so formed may then be physically and electrically joined at various locations by a combination of stitching, welding, and/or other joining means, preferably with interposed insulating layers, to form a multilayer flexible circuit.

Sensing and Display of Skin Conductivity

Filing Date October 18, 1999
MIT Case Number 8599T
US Patent Number 6,415,176
Issue Date July 2, 2002

Inventors Jocelyn Scheirer, Rosalind Picard, Nancy Tilbury, Jonathan Farringdon

A skin-conductivity sensor is configured as a wearable device, such as an article of clothing worn on the hand but covering it only partially. The device may include an on-board power source and a source of illumination that provides a continuous visual indication of skin conductivity.

Frequency-based Wireless Monitoring and Identification Using Spatially Inhomogenous Structures

Filing Date October 10, 2000
MIT Case Number 8313T
U.S. Patent Number 6,724,310
Issue Date March 20, 2004
Inventors Richard Fletcher, Neil Gershenfeld

Wireless tags have a plurality of non-equivalent current pathways, each of which responds differently to an interrogation signal and collectively represent encoded information. The element is subjected to the signal, stimulating the current pathways, each of which contributes to an overall element response. The individual contributions and, hence, the information may be recovered from this overall response. The response of each of the pathways to the signal may vary in terms of one or more of resonant frequency, amplitude, damping, and Q factor.

High-density Data Storage Using Atomic Force Microscope

Filing Date October 6, 2000
MIT Case Number 8634T
U.S. Patent Number 6,519,221
Issue Date February 11, 2003

Inventors Emily Cooper, Hongjie Dai, Hongbin Fang, Scott Manalis, Kazuhiko Matsumoto, Calvin Quate

An atomic force microscope (AFM) tipped with a single-wall conductive nanotube is operated to write bits onto a metal substrate by oxidizing the surface. The oxidized microregions project above an otherwise flat surface, and can therefore be detected—that is, the written bits can be read—using the same AFM arrangement.

High-Sensitivity Interferometric Accelerometer

Filing Date January 7, 2000
MIT Case Number 8678T
U.S. Patent Number 6,473,187B1
Issue Date October 29, 2002

Inventor Scott Manalis

An accelerometer facilitates optical, interferometric measurement of acceleration. The device includes a proof mass having a first set of spaced-apart, elongated fingers projecting therefrom, and a stationary housing or substrate comprising a second set of similarly arranged projecting fingers. A spring connects the proof mass to the substrate such that, in a rest configuration, the first and second set of fingers interdigitate. When the structure is accelerated, the substrate fingers remain stationary, while the alternating fingers of the proof mass are displaced therefrom. This creates a phase-sensitive diffraction grating which, when illuminated, facilitates determination of the relative displacement between the sets of fingers by measuring the intensity of the diffracted modes. This displacement, in turn, indicates the acceleration experienced by the accelerometer structure.

Wireless Monitoring and Identification Using Spatially Inhomogeneous Structures

Filing Date July 14, 2000
MIT Case Number 8313T
U.S. Patent Number 6,472,987
Issue Date October 29, 2002

Inventors Neil Gershenfeld, Richard Fletcher

Tags encode information by means of spatial inhomogeneities that may be detected in the time domain; in effect, characteristics in space are transformed into time for sensing purposes. Such tags may be very inexpensively produced yet carry appreciable quantities of data. The inhomogeneities may be obtained by simple physical modifications to, or externally applied field biases operating on, materials that are very inexpensive to procure.

Multi-Axis Tracking of Passive Resonant Structures

Filing Date June 19, 2000
MIT Case Number 8780T
U.S. Patent Number 6,404,340
Issue Date June 11, 2002

Inventors Joseph Paradiso, Kai-yuh Hsiao

A preferred reader circuit for energizing the coils and detecting loading variations is shown in Figures 3A and 3B. It was designed for tabletop operation at relatively low frequencies; the amplitudes, frequencies, and time con-straints listed below can be shifted as desired for other applications. The depicted schematic includes driver circuitry for three coils, it being understood that further drivers can be added as indicated in the figure. Each driver circuit includes an inductive bridge wherein a search coil 305.sub.1, 305.sub.2, 305.sub.3 is balanced against a series of reference inductors 307.sub.1, 307.sub.2, 307.sub.3 ; 309.sub.1, 309.sub.2, 309.sub.3; and 331.sub.1, 311.sub.2, 311.sub.3 (the latter being variable to trim residuals in the search coil's inductance).

A representative pair of search coils 305.sub.1, 305.sub.2 are identically wound and driven together, and the sensing volume between them is once again indicated at 200. Coil 305.sub.3 may be one of another coil pair, or may instead be a non-aligned search coil used to resolve orientation-related ambiguities with respect to coils 305.sub.1, 305.sub.2.

Methods and Apparatus for Manufacturing Bioelectric Devices

Filing Date June 8, 2000
MIT Case Number 8492T
U.S. Patent Number 6,815,218
Issue Date November 9, 2004

Inventors Joseph Jacobson, Scott Manalis, Brent Ridley

Bioelectronic components are formed using nanoparticles surrounded by attached shells of at least one biological material. The nanoparticles are deposited (e.g., using a printing process) onto a surface, and by associating the deposited nanoparticles with one or more electrical contacts, electrical measurement across the nanoparticles (and, consequently, across the biological material) may be made. A finished component may include multiple layers formed by nanoparticle deposition.

Wireless Monitoring of Temperature

Filing Date April 12, 2000
MIT Case Number 8217T
U.S. Patent Number 6,208,253
Issue Date March 27, 2001

Inventors Richard Fletcher, Neil Gershenfeld

The present disclosure pertains to a wireless sensor which is capable of measuring temperature. This sensor is made entirely of materials and contains no chip or electronics. This sensor can monitor continuous temperature or just respond to a particular temperature setpoint. The sensor can also be made to record history, in the sense that it can be made to undergo a permanent change when subjected to a temperature above a certain threshold. Such a sensor can be integrated into so-called "smart labels" or "smart packaging materials" where a measurement or history of temperature is of interest (e.g. food products).

Fabrication of Finely Features Devices by Liquid Embossing

Filing Date March 14, 2000
MIT Case Number 8661T
U.S. Patent Number 6,517,995
Issue Date February 11, 2003

Inventors Joseph Jacobson, Colin Bulthaup, Eric Wilhelm, Brian Hubert

Elastomeric stamps facilitate direct patterning of electrical, biological, chemical, and mechanical materials. A thin film of material is deposited on a substrate. The deposited material, either originally present as a liquid or subsequently liquefied, is patterned by embossing at low pressure using an elastomeric stamp having a raised pattern. The patterned liquid is then cured to form a functional layer. The deposition, embossing, and curing steps may be repeated numerous times with the same or different liquids, and in two or three dimensions. The various deposited layers may, for example, have varying electrical characteristics, interacting so as to produce an integrated electronic component.

Rolling Toy with Motion Recording and Playback Capability

Filing Date March 9, 2000
MIT Case Number 8367T
U.S. Patent Number 6,354,842
Issue Date March 12, 2002

Inventor Philipp Frei

A rolling device in the form of a two-wheeled toy can record and play back physical motion. In a "training mode," the user grasps the device and draws it along a surface on a desired path. The motion is sensed and recorded in an internal memory. In a "playback mode," the previously imparted motion is repeated—i.e., executed by internal circuitry based on the recorded motion, preferably over and over.

Methods for Manufacturing Electronic and Electromechanical Elements and Devices by Thin-film Deposition and Imaging

Filing Date March 3, 2000
MIT Case Number 8407T
U.S. Patent Number 6,348,295
Issue Date February 19, 2002

Inventors Saul Griffith, Joseph Jacobson, Scott Manalis

Electrically (and, possibly, mechanically) active patterns are applied using a colloidal suspension of nanoparticles that exhibit a desired electrical characteristic. The nanoparticles are surrounded by an insulative shells that may be removed by therefrom by application of energy (e.g., in the form of electromagnetic radiation or heat). The nanoparticle suspension is applied to a surface, forming a layer that is substantially insulative owing to the nanoparticle shells. The applied suspension is exposed to energy to remove the capping groups and fuse the particles into cohesion. If the nanoparticle suspension was deposited as a uniform film, the energy is applied in a desired pattern so that unexposed areas remain insulative while exposed areas exhibit the electrical behavior associated with the nanoparticles. If the nanoparticle suspension was deposited in a desired pattern, it may be uniformly exposed to energy. Additional layers may be applied in the same manner, one over the other, to form a multilayer device.

Management of Properties for Hyperlinked Video

Filing Date March 3, 2000
MIT Case Number 8643T
U.S. Patent Number 6,642,940
Issue Date November 4, 2003

Inventors Jonathan Dakss, Nuno Vasconcelos, Edmond Chalom, V. Michael Bove, Jr.

The process of identifying and associating information with objects in a hyperlinked video sequence is automated by creating an accessible list of object information, including semantic representations, which updates with the identification of new objects. Because objects appear in more than one shot in many video sequences, the invention makes guesses about the identification of objects in a newly segmented sequence. If it guesses the object correctly, the author is relieved of the need to manually search a database of object information to make the association.

Identification and Verification Using Complex, Three-Dimensional Structural Features

Filing Date October 19, 1999
MIT Case Number 8375T
US Patent Number 6,584,214
Issue Date June 24, 2003

Inventors Neil Gershenfeld, Ravikanth Pappu, Joshua Smith

Three-dimensional characteristics of a complex physical structure are used to generate a unique identifier. In effect, the characteristics reperesent the basis of a “physical one-way hash function” that faciliates ready derivation of an identifier based on the physical structure, the structure itself being very difficult to reproduce given only the identifier. The characteristics may be read using a non-contact probe and without the need for precise registration.

Method and Apparatus for Touch-Activated Identification and Information Transfer

Filing Date October 19, 1999
MIT Case Number 8334T
US Patent Number 6,642,837
Issue Date November 4, 2003

Inventors Benjamin Vigoda, Neil Gershenfeld

Physical structures respond to proximity or touch, conveying to a reader information such as the identity of the structure or some data associated therewith. In its simplest form, the structure comprises an electrical load and a pair of electrodes connected thereto. The electrodes are spaced apart (by air or other dielectric medium). A signal generator, which acts as a “reader,” is connected to a larger electrode that may be embedded in an environmental surface. When the structure is placed in proximity to the reader electrode, application of the signal results in capacitive coupling between the reader and the electrodes of the structure. The structure is not detected by the reader, however, because the capacitive coupling

is comparable for both electrodes, so the load experiences only a small electrical gradient. But if one of the electrodes is grounded, this symmetry is broken and current is drawn through the load. In general, grounding occurs when a person, coupled (even weakly) to environmental ground—e.g., by virtue of standing on the floor—touches one of the electrodes. The resulting loading, which may be varied over time by the structure, is detected by the signal generator.

High Density Mechanical Memory and Tuning Machine

Filing Date September 30, 1999
MIT Case Number 8215T
U.S. Patent Number 6,587,408
Issue Date July 1, 2003

Inventors Joseph Jacobson, Brian Hubert, Brent Ridley

Micron-scale, self-contained, ultra-high density and ultra-high speed storage devices include a read/write head and a surface, containing bit-storage domains, that acts as the storage medium. The read/write element of the memory device may consist of a single or multiple heads. The read/write head may be mounted on microelectromechanical structures driven at mechanical resonance. Addressing of individual bits is accomplished by positioning of the head element in close proximity to bit domains situated on the storage medium.

Nanoparticle-Based Electrical, Chemical, and Mechanical Structures and Methods of Making Same

Filing Date June 17, 1999
MIT Case Number 8216T
U.S. Patent Number 6,294,401
Issue Date September 25, 2001

Inventors Joseph Jacobson, Brian Hubert, Brent Ridley, Babak Nivi, Sawyer Fuller

Nanoparticles are utilized to create, through deposition and patterning, functional electronic, electromechanical, and mechanical systems. At sizes ranging from 1 to 999 nm, the ratio of surface atoms to interior atoms becomes non-negligible, and particle properties therefore lie between those of the bulk and atomic materials. Monodisperse (i.e., uniformly sized) or polydisperse nanoparticles can form stable colloids or suspensions in appropriate dispersing media, facilitating their deposition and processing in a liquid state. As a result, printing technology can be utilized to deposit and pattern nanoparticles for mass production or for personal desktop manufacturing.

Parametric Audio System

Filing Date April 27, 1999
MIT Case Number 8077T
U.S. Patent Number 6,775,388
Issue Date August 10, 2004

Inventor Joseph Pompei

Sonic transducers utilize resonant cavities of varying depths to achieve wide operational bandwidth. The transducers may include a conductive membrane spaced apart from one or more backplate electrodes. In one approach, spacing is achieved using a dielectric spacer having a series of depressions arranged in a pattern, the depressions forming cavities each resonant at a predetermined frequency. In another approach, the conductive membrane is piezoelectrically active, and the transducer is simultaneously driven in both piezoelectric and electrostatic modes.

Memory Structures and Methods of Making Same

Filing Date April 14, 1999
MIT Case Number 8214T
U.S. Patent Number 6,072,716
Issue Date June 6, 2000

Inventors Joseph Jacobson, Brian Hubert

Electrically erasable and rewritable memory structures with reversible states and good retention times may be constructed on flexible substrates using simple room-temperature deposition (e.g., printing) processes and curing temperatures below 110° C. The memory structures are based on a polymer matrix having dispersed therein a particulate conductive or semiconductive material. When electrodes of suitable composition and geometry are used to apply electrical pulses of opposite polarity to the matrix material, reversible memory switch-

ing behavior is observed. In particular, subjection to positive or negative voltage pulses causes the devices to make fully-reversible transitions between low-resistance and high-resistance states.

Dynamic Holographic Video with Haptic Interaction

Filing Date February 9, 1999
MIT Case Number 8010T
U.S. Patent Number 6,211,848
Issue Date April 3, 2001

Inventors Wendy Plesniak, Ravikanth Pappu, Stephen Benton

We describe the implementation of a system which enables a user to interact with and modify an electronic holographic image using a force-feedback device. The force-feedback (or haptic) device is capable of sensing and reporting the 3D position of its hand-held stylus and displaying appropriate forces to the user. Thus, a user can feel and modify algorithmically specified shapes in the haptic workspace. We precisely register the haptic workspace with the free-standing, spatial image displayed by the MIT second generation holographic video system (holovideo). In the coincident visuo-haptic workspace, a user can see, feel, and interact with synthetic objects that exhibit many of the properties one expects of real ones, and the spatial display enables synthetic objects to become a part of the user's manipulatory space. To the best of the authors' knowledge, this is the first time that such an interactive holographic system has been built.

Apparatus for Resolving Presence and Orientation within a Defined Space

Filing Date January 25, 1999
MIT Case Number 7295T C2
U.S. Patent Number 6,066,954
Issue Date May 23, 2000

Inventors Neil Gershenfeld, Joshua Smith

Apparatus for resolving movement of a mass within a defined space utilizes at least one electrode proximate to the space to be observed. An AC signal is applied to the electrode, and the current measured from that electrode and also to any other electrodes included in the system, and which are effectively connected to the ground return of the AC-coupled electrode. A person (or object) to be sensed intercepts a part of the electric field extending beween the AC-coupled "sending" electrode and the other "receiving" electrodes, the amount of the field intercepted depending on the size and orientation of the sensed person, whether or not the person provides a grounding path, and the geometry of the distributed electrodes. Given the nonlinear spatial dependence of the field, multiple electrodes can reliably distinguish among a set of expected cases. The invention detects motion by taking sequential measurements at different times and utilizing the time variation in signal magnitudes as well as the absolute magnitudes themselves.

Heterogeneous Display Elements and Methods for Their Fabrication

Filing Date December 7, 1998
MIT Case Number 7690T
U.S. Patent Number 6,241,921
Issue Date June 5, 2001

Inventors Joseph Jacobson, Hidekazu Yoshizawa

Optically heterogeneous display elements utilize fused pigment particles, which may be manufactured with polymer shells having desired charge, photoresponse, or density characteristics. The particles may be microencapsulated prior to formation of the display element, so that the element is formed internally within the container in which it is permanently housed. The element may function as a bichromal display, a light valve, or a programmable magnetic element.

Method and Apparatus for Determining Three-Dimensional Position, Orientation and Mass Distribution

Filing Date November 30, 1998
MIT Case Number 7294T P2
U.S. Patent Number 6,025,726
Issue Date February 15, 2000

Inventors Neil Gershenfeld, Joshua Smith

A quasi-electrostatic sensing system surrounds an electrically conductive mass with an electric field, the magnitude of which is sensed at one or more locations to resolve a property of interest concerning the mass. The object intercepts a part of the electric field extending between the AC-coupled "sending" electrode and the other "receiving" electrodes, the amount of the field intercepted depending on the size and orientation of the sensed mass, whether or not the mass provides a grounding path, and the geometry of the distributed electrodes. Because the response of the field to an object is a complex nonlinear function, adding electrodes can always distinguish among more cases. In other words, each electrode represents an independent weighting of the mass within the field; adding an electrode provides information regarding that mass that is not redundant to the information provided by the other electrodes. A "forward model" that relates the behavior of the system to variations in the property to be measured is established, and "inversion" of this model facilitates recovery of the property based on system behavior. The invention is amenable to a wide variety of usages including the detection of user positions and gestures as a means of conveying two- and/or three-dimensional information to, for example, computers, appliances, televisions, furniture, etc.; provision of data input or instructional commands to a device; or sensing of proximity to a reference object for security purposes, to warn of danger, or to conserve energy by withholding power until a potential user approaches the object.

Method and Apparatus for Characterizing Movement of a Mass within a Defined Space

Filing Date November 30, 1998
MIT Case Number 7295T D2
U.S. Patent Number 6,051,981
Issue Date April 18, 2000

Inventors Neil Gershenfeld, Joshua Smith

Apparatus and methods for resolving movement of a mass within a defined space utilizes at least one electrode proximate to the space to be observed. An AC signal is applied to the electrode, and the current measured from that electrode and also to any other electrodes included in the system and which are effectively connected to the ground return of the AC-coupled electrode. A person (or object) to be sensed intercepts a part of the electric field extending beween the AC-coupled "sending" electrode and the other "receiving" electrodes, the amount of the field intercepted depending on the size and orientation of the sensed person, whether or not the person provides a grounding path, and the geometry of the distributed electrodes. Given the nonlinear spatial dependence of the field, multiple electrodes can reliably distinguish among a set of expected cases. The invention detects motion by taking sequential measurements at different times and utilizing the time variation in signal magnitudes as well as the absolute magnitudes themselves.

Autostereoscopic Display System

Filing Date November 20,1998
MIT Case Number 8155T
US Patent Number 6,351,280
Issue Date February 26, 2002

Inventor Stephen Benton

An autostereoscopic display system is capable of tracking one or more users within a viewing zone and presenting complementary stereo images to each of the viewer's (or viewers') eyes. Polarization is used to segregate the images that are to be directed to different spatial regions. The two images are interdigitated within a single display —that is, each band of image points from the first image alternates with a band of image points from the second image on the display. The bands of the first image are polarized in a first mode and the bands of the second image are polarized in a second mode orthogonal to the first, e.g., through use of a liquid-crystal display (LCD) in which alternating, contiguous bands of pixels correspond to bands of one or the other image, and a "patterned polarizer" also organized into bands and aligned with the pixel bands. Autostereoscopic viewing is facilitated by a display (such as an LCD) that is illuminated by light from an outside source whose polarization can be controlled. Illumination from the light source passes through a focusing lens and then through the patterned polarizer and display so as to form a "real" or "aerial" image of the display in the viewing zone, with the different images directed to different regions of the viewing zone.

Nonemissive Displays and Piezoelectric Power Supplies therefor

Filing Date November 10, 1998
MIT Case Number 7514T C1
U.S. Patent Number 6,130,773
Issue Date October 10, 2000

Inventors Joseph Jacobson, Barrett Comiskey

An electrophoretic display has a substantially two-dimensional arrangement of microcapsules each having therein an electrophoretic composition of a dielectric fluid and a suspension of particles that visually contrast with the dielectric liquid and also exhibit surface charges; a pair of electrodes, at least one of which is visually transparent, disposed on and covering opposite sides of the microcapsule arrangement; and a power source for creating a potential difference between the two electrodes, the potential difference causing the particles to migrate toward one of the electrodes. The display may be powered by one or more piezoelectric elements, which are also suitable for powering other types of nonemissive displays.

Multiple Viewer Auto-Stereoscopic Display Systems

Filing Date September 2, 1998
MIT Case Number 7746T
U.S. Patent Number 6,593,957
Issue Date July 15, 2003

Inventor Paul Christie

Autostereoscopic image displays provide highly realistic three-dimensional images to one or a plurality of viewers without the need for wearable appliances. In some embodiments, the images are viewed through a beamsplitter, while in other embodiments the viewer observes the images on a display screen. A viewer-tracking system monitors the viewer's movements and directs each image of a stereopair to the proper eye of the viewer. In some embodiments, the stereoimages are kept independent and separately directed through differential polarization. In other embodiments, this is accomplished through selective intensity modulation.

Apparatus and Methods for Reversible Imaging of Nonemissive Display Systems

Filing Date July 10, 1998
MIT Case Number 7932T
U.S. Patent Number 6,291,925
Issue Date September 18, 2001

Inventor Joseph Jacobson

The present invention teaches a reversible printing system comprising an electrostatic write head which may reversibly address a bistable electronic ink surface. Such a system may be employed to reversibly write text or images on an arbitrary surface with no consumable such as a credit card, phone card, cash card, transportation card, paper or newspaper sized sheet, book, cloth or clothing, toy or product. Another implementation of the system is a reversible electrophotographic system. Other aspects of the invention include a hybrid electronic camera.

Method and Apparatus for Automated, Context-Dependent Retrieval of Information

Filing Date May 1, 1998
MIT Case Number 7870TS
U.S. Patent Number 6,236,768
Issue Date May 22, 2001

Inventors Bradley Rhodes, Thad Starner, Pattie Maes, Alex Pentland

Documents stored in a database are searched for relevance to contextual information, instead of (or in addition to) similar text. Each stored document is indexed in terms of meta-information specifying contextual information about the document. Current contextual information is acquired, either from the user or the current computational or physical environment, and this "meta-information" is used as the basis for identifying stored documents of possible relevance.

System and Method for Multicast Video-on-Demand Delivery System

Filing Date April 24, 1998
MIT Case Number 7973T
U.S. Patent Number 6,018,359
Issue Date January 25, 2000

Inventors Roger Kermode, Henry Holtzman

Traditional Video-on-Demand (VoD) schemes scale in direct proportion to the available head end server storage and network bandwidth. Each viewer is allocated a dedicated network channel and an access slot on a remote server. When no more network channels or server access slots are available subsequent requests for service are denied. Some VoD schemes achieve greater scalability by merging requests from multiple viewers and require receivers to store data temporarily before playback. These schemes are called user-centered since network channel allocation is determined in response to user or viewer requests. Data-centered schemes take the other approach and allocate network channels in advance. Receivers then determine on their own which channels to listen to in order to receive a movie segment in time for playback.

Our scheme is data-centered and incorporates several new features not present in previous schemes. In our scheme movies are divided into a number of segments. Each segment is transmitted continuously in a loop on its own network channel. Receivers tune in to at most two channels at any given time.The length of each segment is chosen so that the receiver is able to receive and cache the segment's entire contents before playing it back. Furthermore, segment lengths are chosen so that successive segments increase in size at a maximum rate, thereby reducing the overall access latency and storage requirement at the receiver. Performance is further increased by allowing the transmission rate of a segment over a network channel to occur at a greater rate than the single speed playback rate of the original movie. Smaller segment sizes are avoided by allowing receivers to cache the first segment from multiple movies ahead of

time. Access to these pre-cached movies is instantaneous. Access to other movies is still possible with slightly increased latency. Finally, our scheme incorporates pruned multicast transmission, thereby allowing the network channels of unused segments to be turned over to segments of other movies. These final two features increase the total number of movies that can be carried for a given amount of network bandwidth.

Method and Apparatus for Data Hiding in Printed Images

Filing Date April 15, 1998
MIT Case Number 7754T
U.S. Patent Number 6,411,392
Issue Date June 25, 2002

Inventors Walter Bender, Daniel Gruhl

A technique for embedding a mark in a printed image allows its interpretation by an inexpensive printing system. Values of a characteristic parameter are altered in a portion of the host image confined to a thread, i.e. a region of contiguous points in the image, small enough to be included in the print space treated by the printer in a single pass of the printing head.

Method and Apparatus for Multi-Bit Zoned Data Hiding in Printed Images

Filing Date April 15, 1998
MIT Case Number 8049T
U.S. Patent Number 6,212,285
Issue Date April 3, 2001

Inventors Walter Bender, Daniel Gruhl

A technique for embedding a tracking number as a series of bits in a printed image alters characteristic parameter values at a set of pseudo-random locations chosen for each bit in an embedding zone. The alteration markedly changes the expectation value of some linear combination of mathematical functions of the values at that set of locations. A marker bit encoded to a higher certainty than other bits in the string aids in orienting the zones in decoding. The tracking number is detected and identified by exploiting the behavior of sums of a large number of random variables, based on the Patchtrack approach.

Electrically Active Resonant Structures for Wireless Monitoring and Control

Filing Date December 4, 1997
MIT Case Number 7550T
U.S. Patent Number 6,025,725
Issue Date February 15, 2000

Inventors Neil Gershenfeld, Richard Fletcher

A planar electromagnetic resonator utilizes an electromagnetically active material located between the capacitive or inductive elements of the resonator. A microscopic electrical property of this material is altered by an external condition, and that alteration, in turn, affects the behavior of the resonator in a consistent and predictable manner.

Method and Apparatus for Data Hiding in Images

Filing Date November 17, 1997
MIT Case Number 7116T C1
U.S. Patent Number 5,870,499
Issue Date February 9, 1999

Inventors Walter Bender, Norishige Morimoto, Daniel Gruhl

A method of hiding a pattern in a host image increases and decreases parameter values at randomly selected host image locations assigned to respective first and second groups. The alteration modifies the statistical behavior of a test statistic equivalent to a linear combination of a large number of instances of respective functions, associated with the pattern, of the parameter values at first and second group locations. The presence or absence of the pattern in a test image is determined by comparing the experimental value of the test statistic associated with the pattern with the expected value of the same sum for an unaltered host image.

Method and Apparatus for Transbody Transmission of Power and Information

Filing Date November 6, 1997
MIT Case Number 7802T
U.S Patent Number 6,211,799
Issue Date April 3, 2001

Inventors Rehmi Post, Babak Nivi, Neil Gershenfeld

Prior art has shown that the human body can be used as a communications channel, by generating and sensing gradient electrostatic fields that perturb the body's average potential relative to the environment. This is advantageous over conventional radio frequency wireless communications for applications such as wearable computers because the small signal external to the body minimizes the occurrence of unintentional interference and intentional eavesdropping, and it permits physical gestures to be associated with digital content so that information can be exchanged by touching people or things. A limitation of this prior art is that the transmitters and receivers require power sources. Using and replacing batteries can be inconvenient, particularly if there are many such elements, and if they are embedded in articles such as shoes.

This invention shows that the signalling fields can safely and simply be designed to contain sufficient energy to energize remote processing elements, permitting power to be distributed from locations where it is easily available to those where it is not. In one embodiment, a power conversion device in a shoe that recovers energy from walking can excite other devices such as a wristwatch; in another embodiment the power source is external to the body in a location such as a doorknob or floor mat. This scheme therefore permits the remotely-powered elements to be permanently encapsulated without requiring later access.

The energy recovery is performed by a processing element that rectifies and stores the current induced by a local gradient field, possibly enhanced by a resonant circuit attached to the detection antenna. This energy is used to energize the local circuitry, in either a steady-state or pulse-ringdown method of operation. The result of the local processing may then be directly transmitted back by modulating a locally-generated gradient field, or for low-power operation it may also be done by modulating the power loading presented to the remote excitation source.

Method of Fabricating Electro-Mechanical Devices by Multilayer Deposition

Filing Date October 27, 1997
MIT Case Number 7457T
U.S. Patent Number 6,200,508
Issue Date March 13, 2001

Inventors Joseph Jacobson, Jonathan Albert, Neil Gershenfeld

Printing techniques are used to build three-dimensional structures by depositing successive layers of the device onto a substrate. The layers and/or portions thereof are different materials, e.g., conductors and insulators, which provide the desired functional characteristics of the device. The substrate may be used only to provide a support for the printing process, in which case it will usually be removed after the device is fabricated, or may instead be a functioning part of the fabricated device.

Method for Resolving Presence, Orientation and Activity in a Defined Space

Filing Date October 8, 1997
MIT Case Number 7295T C1
U.S. Patent Number 5,936,412
Issue Date August 10, 1999

Inventors Neil Gershenfeld, Joshua Smith

A method for resolving presence, orientation and activity of a person within a defined space utilizes at least two electrodes proximate to the space to be observed. A characterization of the position and orientation is obtained by providing a pattern of measurement clusters each associated with a position and an orientation. An AC signal is applied to one electrode, and the current measured from that electrode to any other electrodes included in the system, and which are effectively connected to the ground return of the AC-coupled electrode. A person (or object) to be sensed intercepts a part of the electric field extending between the AC-coupled "sending" electrode and the other "receiving" electrodes, the amount of the field intercepted depending on the size and orientation of the sensed person, whether or not the person provides a grounding path, and the geometry of the distributed electrodes. Given the nonlinear spatial dependence of the field, multiple electrodes can reliably distinguish among a set of expected cases. The invention can be configured to detect not only static positions and orientations, but also motion through a defined space. This is accomplished by taking sequential measurements at different times and utilizing the time variation in signal magnitudes as well as the absolute magnitudes themselves.

Electrically Active Textiles and Articles Made Therefrom

Filing Date September 24, 1997
MIT Case Number 7813T
U.S. Patent Number 6,210,771
Issue Date April 3, 2001

Inventors Rehmi Post, Margaret Orth, Emily Cooper, Joshua Smith

The present invention teaches both a new type of electronic sensing device, hereinafter called electronic textile switches and sensors, and a means of fabricating electronic textile devices in general, including touch- and humidity-sensitive keyboards and surfaces. Such electronic textile devices may be used to interface to wearable computing systems, toys, and other digital systems requiring light weight, durability, mechanical flexibility, and washability. The electronic textile devices are described in a manner which lends itself to manufacture using current textile processes.

Digital Communication, Programmable Functioning and Data Transfer Using Modular, Hinged Processor Elements

Filing Date September 23, 1997
MIT Case Number 7700T
U.S. Patent Number 5,941,714
Issue Date August 24, 1999

Inventors Matthew Gorbet, Margaret Orth

A computational device, consisting of a group of (two or more) tiling geometric objects (tiles) which pass digital information through a flexible (hinge-like), conducting edge connector, such that specific information about their identities and spatial relationships (the overall topography of the system) and any changes (connection or disconnection events) can be known to an internal processor or communicated to an external processor. These tiles can also perform special-purpose electronic or computation tasks, depending on the device's application (such as sensing or visual display).

Essential properties of the edge connectors include (a) the ability to pass data signals of the form commonly used by computation devices, (b) the ability to simultaneously create an electrical data connection and a mechanical joint by immediate physical contact, and (c) the ability to hinge, maintaining contact while flexing, in order to construct two dimensional or three dimensional

structures. Examples of applicable connection mechanisms include magnetic connectors, conductive hook and loop fasteners (Velcro®), and conductive fabric-based connectors. Such a system has the prospect of becoming a new interface (input/output) device to existing or future computational systems, or acting as a stand-alone modular computational device.

Method of Creating a High Resolution Still Image Using a Plurality of Images and Apparatus for Practice of the Method

Filing Date August 8, 1997
MIT Case Number 5717T CIP1 C1
U.S. Patent Number 5,920,657
Issue Date July 6, 1999

Inventors Walter Bender, Laura Teodosio

The invention is a method for generating a still image, comprising the steps of producing a plurality of images, each of the plurality having been produced at a distinct focal length, scaling each of the images to a common focal length and combining each of the scaled images to a final image of a single focal length, portions of which are of a relatively high resolution, as compared to the images of the original sequence. The invention also includes combining a sequence of still images of varying fields of view into a panoramic image of an overall field of view, which overall field of view includes all of the fields of view of the sequence. In addition to combining images generated at different fields of view, the method of the invention can be used to combine images generated with respect to different fields of view of an overall scene, such as a panoramic scene into a combined panoramic field of view. This aspect of the invention may also be combined with the varying focal length aspect. Even without varying the focal length or the field of view, the invention can be used to produce a composite image of enhanced resolution relative to the resolution of any of the images of the original sequence. The invention is also an apparatus for generating a still image, comprising means for producing a plurality of images, each of the plurality having been produced at a distinct focal length, the focal lengths differing from each other, means for scaling each of the plurality of images to a common focal length and means for combining each of the scaled images into a single image of a single focal length. The apparatus of the invention also includes apparatus to combine images generated with respect to different fields of view of an overall scene into a combined panoramic field of view.

Non-Contact System for Sensing and Signalling by Externally Induced Intra-Body Currents

Filing Date August 6, 1997
MIT Case Number 6788T C1
U.S. Patent Number 5,914,701
Issue Date June 22, 1999

Inventors Neil Gershenfeld, Thomas Zimmerman, David Allport

Small (typically nanoamp) current flow in biological tissue in a weak varying applied electric field (typically 1V/cm) will, with adequate shielding, sensitive current amplifiers, and coherent detection, be easily and inexpensively measured. Such a current can remotely be injected into one part of the body (for example, by electrodes under a carpet or the seat of a chair) and then received from another (for example, by electrodes in the wall or the armrests) in order to measure the strength and thereby locate the relevant part (the body in the room, or the arms in space around the chair). Alternatively, the current can be induced by an appliance in a field (such as a pen with a metallic interior) and then coupled (by the arm in this example) to a receive electrode (under the handrest in the example) in order to use the body to replace the wires

carrying signals from the appliance. Finally, information can be encoded in the varying current to communicate between intelligent devices on or near the body and the external environment via receiving electrodes (for example in chairs or carpets). This provides a wireless, low-power personal data network that does not require radiated RF energy.

Self-Organizing Network

Filing Date July 25, 1997
MIT Case Number 7552T
U.S. Patent Number 6,028,857
Issue Date February 22, 2000

Inventor Robert Poor

A self-organizing wireless network includes a plurality of nodes, each of which is configured to originate messages, be a destination of messages and relay messages. Each message is transmitted in a frame that includes the cost of conveying the message to the destination node for the message and also the cost so far expended in the conveying of the message. Each time the message frame is transmitted, either by the originating node or by a relaying node, the node ascertains whether the cost to convey the message from that node to the destination node is less than the conveying cost contained in the received frame. If it is, the node retransmits the frame after having incremented the incurred cost by the relay cost of that node and decremented the cost to convey by the same value. Otherwise the node discards the message.

Rear View Mirror with Integrated Matrix Display

Filing Date July 10, 1997
MIT Case Number 8322T
U.S. Patent Number 6,106,121
Issue Date August 22, 2000

Inventors Stephen Buckley, Betty Lou McClanahan

A rear view mirror includes a transparent front glass that covers a matrix display, for example an LCD display. The matrix display is translucent when activated and transparent when inactive, and behind the matrix display is a mirror-backed rear glass. Thus, light can pass through the matrix display and reflect back off the mirror-backed rear glass. Consequently, the rear view mirror can assume its conventional function of presenting images of objects that are behind the vehicle, while the pixels of the matrix display can be activated to superimpose alphanumeric characters on the images. The characters can represent vehicle speed, time, radio station data, or other vehicle control data.

Method and Apparatus for Producing Binaural Audio for a Moving Listener

Filing Date June 18, 1997
MIT Case Number 7633T
U.S. Patent Number 6,243,476
Issue Date June 5, 2001

Inventor William Gardner

A system for generating loudspeaker-ready binaural signals comprises a tracking system for detecting the position and, preferably, the angle of rotation of a listener's head; and means, responsive to the head-tracking means, for generating the binaural signal. The system may also include a crosstalk canceller responsive to the tracking system, and which adds to the binaural signal a crosstalk cancellation signal based on the position (and/or the rotation angle) of the listener's head. The invention may also address the high-frequency components not generally affected by the crosstalk canceller by considering these frequencies in terms of power (rather than phase). By implementing the compensation in terms of power levels rather than phase adjustments, the invention avoids the shortcomings heretofore encountered in attempting to cancel high-frequency crosstalk.

Apparatus and Method for Characterizing Movement of a Mass within a Defined Space

Filing Date April 2, 1997
MIT Case Number 7295T D1
U.S.Patent Number 5,914,610
Issue Date June 22, 1999

Inventors Neil Gershenfeld, Joshua Smith

Apparatus and methods for resolving movement of a mass within a defined space utilizes at least one electrode proximate to the space to be observed. An AC signal is applied to the electrode, and the current measured from that electrode and also to any other electrodes included in the system and which are effectively connected to the ground return of the AC-coupled electrode. A person (or object) to be sensed intercepts a part of the electric field extending beween the AC-coupled "sending" electrode and the other "receiving" electrodes, the amount of the field intercepted depending on the size and orientation of the sensed person, whether or not the person provides a grounding path, and the geometry of the distributed electrodes. Given the nonlinear spatial dependence of the field, multiple electrodes can reliably distinguish among a set of expected cases. The invention detects motion by taking sequential measurements at different times and utilizing the time variation in signal magnitudes as well as the absolute magnitudes themselves.

Printable Electronic Display

Filing Date March 18, 1997
MIT Case Number 7646T
U.S.Patent Number 6,980,196
Issue Date December 27, 2005

Inventors Christopher Turner,
Joseph M. Jacobson, Barrett Comiskey

A display system includes a substrate upon which the display system is fabricated; a printable electrooptic display material, such as a microencapsulated electrophoretic suspension; electrodes (typically based on a transparent, conductive ink) arranged in an intersecting pattern to allow specific elements or regions of the display material to be addressed; insulating layers, as necessary, deposited by printing; and an array of nonlinear elements that facilitate matrix addressing. The nonlinear devices may include printed, particulate Schottky diodes, particulate PN diodes, particulate varistor material, silicon films formed by chemical reduction, or polymer semiconductor films. All elements of the display system may be deposited using a printing process.

Microencapsulated Electrophoretic Display

Filing Date March 18, 1997
MIT Case Number 7645T
U.S. Patent Number 5,961,804
Issue Date October 5, 1999

Inventors Joseph Jacobson, Barrett Comiskey,
Jonathan Albert

An application-ready electrophoresis material includes a carrier and a dispersion of microcapsules therein, the microcapsules each containing a plurality of phases therein. At least some of the phases contrast visually and exhibit differential responsiveness to an electric field, such that application of the field determines the visual appearance of the microcapsules. The material exhibits stability such that the visual appearance persists despite removal of the field. In one aspect, the invention provides for enhanced stability of the visual appearance. In another aspect, the reflectivity of at least one of the phases is enhanced. In another aspect, one of the phases is particulate in nature and emits visible radiation.

Apparatus for Controlling Continuous Behavior through Hand and Arm Gestures

Filing Date March 7, 1997
MIT Case Number 7566T
U.S. Patent Number 5,875,257
Issue Date February 23, 1999

Inventors Teresa Marrin, Joseph Paradiso, Tod Machover, Christopher Verplaetse, Margaret Orth

Apparatus for continuous sensing of hand and arm gestures comprises hand-held means for continuously sensing at least tempo and emphasis. These sensed parameters are represented quantitatively, and transduced by appropriate circuitry into electrical signals indicative of the parameter quantities. The signals may be used to control the performance of a musical composition (or the evolution of some other dynamic system), or may instead convey information. The signals may, for example, be provided to an interpreter that dynamically infers control commands from the gestures on a real-time basis in accordance with the generally accepted canon of musical conducting, directing the controlled system in accordance therewith. The invention may also sense one or more additional conducting parameters such as the speed and/or velocity, direction (i.e., trajectory) in three dimensions, absolute three-dimensional position, the "size" of a gesture in terms of the spatial distance between successive beats, and the "placement" of a beat pattern in space.

Efficient Synthesis of Complex, Driven Systems

Filing Date January 17, 1997
MIT Case Number 7523T
U.S. Patent Number 6,000,833
Issue Date December 14, 1999

Inventors Neil Gershenfeld, Bernd Schoner, Eric Metois

Efficient synthesis of complex, driven systems is accomplished using a probabilistic framework according to which the physics of system behavior are modeled in terms of the effective degrees of freedom relevant to observed behavior, instead of modeling the physical configuration or the output waveform. A replica of the system's behavior in response to external stimulus is developed computationally, and the model used to replace (or facilitate replacement) of the system with, for example, a physical representation programmed to behave in accordance with the model. The invention may be applied to develop a model capturing the behavior of a complex musical instrument such as a violin; the model then may be embodied in any physically appealing format (e.g., as a plastic replica of the original violin that would, absent the implemented model, produce no sound if bowed; or a keyboard or other musical instrument whose response to being "played" is to generate the sounds of the original violin).

Nonemissive Displays and Piezoelectric Power Supplies Therefor

Filing Date October 25, 1996
MIT Case Number 7514T
U.S. Patent Number 5,930,026
Issue Date July 27, 1999

Inventors Joseph Jacobson, Barrett Comiskey

An electrophoretic display has a substantially two-dimensional arrangement of microcapsules each having therein an electrophoretic composition of a dielectric fluid and a suspension of particles that visually contrast with the dielectric liquid and also exhibit surface charges; a pair of electrodes, at least one of which is visually transparent, disposed on and covering opposite sides of the microcapsule arrangement; and means for creating a potential difference between the two electrodes, the potential difference causing the particles to migrate toward one of the electrodes. The display may be powered by one or more piezoelectric elements, which are also suitable for powering other types of nonemissive displays.

Method and Apparatus for Quantum Information Processing

Filing Date October 8, 1996
MIT Case Number 7490T
U.S. Patent Number 5,917,322
Issue Date June 29, 1999

Inventors Neil Gershenfeld, Isaac Chuang

According to the theory of quantum computation, a quantum computer can implement many algorithms significantly faster than a conventional classical computer. In particular, it can find prime factors in polynomial time instead of exponential time, breaking classical cryptography. For this reason, there has been a significant experimental effort to build a quantum computer. These efforts have all failed to date, because of the difficulty in manipulating a system so that it performs the desired quantum computation, and simultaneously is sufficiently isolated from its environment so that it does not decohere. Prior efforts have all been based on isolating individual quantum degrees of freedom, through means such as ion traps, cavity quantum electrodynamics, and nanofabricated dots. All of these approaches suffer from significant problems with decoherence, and with the ability to scale up to larger systems.

This invention teaches a new entirely different approach based on bulk samples. It is based on using multiple pulse resonance techniques on a sample such as a liquid containing an enormous number of identical molecules. The quantum degrees of freedom are contained in coherences in the small deviations of the density matrix for the ensemble from its thermodynamics limit. The initial condition is loaded by applying a pulse sequence based on knowledge of the thermodynamic equilibrium. Then the computation proceeds with further pulses that use spin interaction terms (such as dipole coupling) as the nonlinearity required for gates such as the controlled-NOT. Finally, readout is performed by sequences that make the desired terms of the density matrix observable. Not only does that method permit any conventional spin resonance apparatus to be used as a quantum computer, the enormous redundancy protects the system from errors and permits continuous observation of the quantum state.

Program-listing Appendix

Filing Date August 22, 1996
MIT Case Number 7333TS
U.S. Patent Number 6,353,822
Issue Date March 5, 2002

Inventor Henry Lieberman

Methods and apparatus for assisting a user in retrieving documents or other data items of interest operates in tandem with a conventional document-retrievalfacility, such as a web browser, by tracking the choices made by the user in retrieving and viewing data items. The invention identifies additional items likely to be of interest to the user. Preferably, the invention operates automously, without interruption of the user's activities, delivering (in real-time or upon request) a set of current recommendations. The recommendations take the form of (or include) links to the recommended items, and the user is free to execute any of these links to examine the contents of a recommendation.

System Employing Dissipative Pseudorandom Dynamics for Communication and Measurement

Filing Date September 12, 1996
MIT Case Number 6781T D1
U.S. Patent Number 5,729,388
Issue Date March 17, 1998

Inventor Neil Gershenfeld

An optical communication and/or measurement system includes a transmitter that modulates a pseudorandom noise signal with a message signal to produce a wide-band signal for transmission. A receiver, which demodulates the wideband signal to recover the message signal, includes an "analog" feedback shift register ("AFSR") that reproduces the noise signal based on samples of the received signal. The AFSR is a generalization of a linear feedback shift register ("LFSR"). The AFSR is characterized by a function that agrees with the function that characterizes the LFSR, at the points at which that function is defined. The AFSR includes beam splitters that are spaced in accordance with the associated pseudorandom code. The AFSR's function has stable fixed points at integer values and unstable fixed points at half-integer values and, the stable fixed points act as attractors. The AFSR thus produces a sequence that relaxes to the nearest integer-valued sequence.

As long as the samples of received signal that are fed to the AFSR fall within the basins of attraction that surround the stable values, the AFSR can accurately determine the expected next state of the shift register. While this can be done explicitly, the AFSR merges the symbol parsing, acquisition, tracking and update rules into a simple governing equation. The AFSR will thus entrain and produce an optical binary-valued pseudorandom noise signal.

Method and Apparatus for Automatic Alignment of Volumetric Images Containing Common Subject Matter

Filing Date June 3, 1996
MIT Case Number 7118T
U.S. Patent Number 5,946,425
Issue Date August 31, 1999

Inventors V. Michael Bove, Jr., Tamas Sandor

Different tomographic images of the same subject matter are optimally related to one another through a two-step procedure whereby, first, movements are plotted on a subregion level, producing a vector map relating subregions in a first set of scan frames to subregions in another set of scan frames; and then, based on the aggregate of subregion movements, the invention characterizes the "global" displacement, relating the volume represented by the first set of scan frames to that represented by the second set. More specifically, the invention generates translation and rotation vectors that describe the movements' underlying shifts in subject matter from one scan to the other, and which can be applied to one frame set to align it with the other.

Method and Apparatus for Echo Data Hiding in Audio Signals

Filing Date May 31, 1996
MIT Case Number 7115T
U.S. Patent Number 5,893,067
Issue Date April 6, 1999

Inventors Walter Bender, Daniel Gruhl, Norishige Morimoto

A method of hiding information in a host audio signal introduces one or more echoes into the signal. The separation in time between the host signal and an echo is associated with the value of a datum embedded in the signal. The identity of the embedded datum is determined by observing the delay between the host signal and the echo.

Method and Apparatus for Producing Digital Images Having Extended Dynamic Ranges

Filing Date May 6, 1996
MIT Case Number 7347T
U.S. Patent Number 5,828,793
Issue Date October 27, 1998

Inventor Steve Mann

Most everyday scenes have a far greater dynamic range than can be recorded on a photographic film or electronic imaging apparatus (whether it be a digital still camera, video, etc.). However, a set of pictures, that are identical except for their exposure, collectively show us much more dynamic range than any single picture. The dark pictures show us highlight details of the scene that would be washed out in a "properly exposed" picture, while the light pictures show us some shadow detail that would also not appear in a "properly exposed" picture. We propose a means of combining differently exposed pictures to obtain a single picture of extended dynamic range and improved color fidelity. Given a set of digital pictures, we may produce a single picture which is, for all practical purposes, 'undigital', in the sense that it is a floating point image, with the kind of dynamic range we are accustomed to seeing in typical floating point representations, as opposed to the integer images from which it was generated.

The method is completely automatic; it requires no human intervention, and it requires no knowledge of the response function of the imaging device. It works reliably with images from a digital camera of unknown response, or from a scanner with unknown response, scanning an unknown film type.

Method for Three-Dimensional Positions, Orientation and Mass Distribution

Filing Date May 1, 1996
MIT Case Number 7294T CIP1
U.S. Patent Number 5,844,415
Issue Date December 1, 1998

Inventors Neil Gershenfeld, Joshua Smith

Capacitance sensing is one of the oldest technologies used for detecting the presence of a person, in applications such as touch-switches and computer pointing devices. The prior art has covered proximity detection and two-dimensional position measurement. It does not recognize the distinct current transport pathways that contribute to such a measurement (loading from a transmitting electrode into a body, the screening of a receive electrode due to shunting from a body into the environment, and coupling through a body into a receiving electrode). An understanding of these physical mechanisms, along with knowledge of the field geometry, can be used to invert a set of displacement current measurements to determine the absolute three-dimensional mass distribution in the field. This invention describes the means to perform such a measurement, interpret the signals, and apply the results.

Bistable, Thermochromic Recording Method for Rendering Color and Gray Scale

Filing Date March 8, 1996
MIT Case Number 7296T
U.S. Patent Number 6,022,648
Issue Date February 8, 2000

Inventors Joseph Jacobson, V. Michael Bove, Jr.

The invention involves printing with thermochromic pigment materials. These materials are typically binary in nature, colored or fully transparent, and can be caused to change state through application of heat. Current material, therefore, are monochromatic. By utilizing recording constructions having particles with different temperatures, the invention facilitates production of full color images having multiple gray scales. For example, in one embodiment, a recording construction has multiple adjacent recording layers each having particles that undergo transition at a different characteristic temperature. A thermal writing head selectively heats the construction in an

imagewise pattern, the heating temperature corresponding to the desired gray level (since higher temperatures will cause transition in more of the layers).

Method and Apparatus for Data Hiding in Images

Filing Date February 9, 1996
MIT Case Number 7116T
U.S. Patent Number 5,689,587
Issue Date November 18, 1997

Inventors Walter Bender, Norishige Morimoto, Daniel Gruhl

A method of hiding a pattern in a host image increases and decreases parameter values at randomly selected host image locations assigned to respective first and second groups. The alteration modifies the statistical behavior of a test statistic equivalent to a linear combination of a large number of instances of respective functions, associated with the pattern, of the parameter values at first and second group locations. The presence or absence of the pattern in a test image is determined by comparing the experimental value of the test statistic associated with the pattern with the expected value of the same sum for an unaltered host image.

Method and Apparatus for Logo Hiding in Images

Filing Date February 9, 1996
MIT Case Number 7117T
U.S. Patent Number 6,201,879
Issue Date March 13, 2001

Inventors Walter Bender, Norishige Morimoto, Daniel Gruhl

A method of hiding a figure in an image replaces information from a figure-shaped portion of the image with information from another location having similar texture. The relative insensitivity of the eye to discontinuities in texture patterns having a significant high-frequency or random component minimizes the perceptibility of the replacement. The figure is revealed by autocorrelating the image containing the repeated information, and subtracting the image from a copy of itself shifted according to the arguments creating large value of the autocorrelation function.

Method and Apparatus for Relating and Combining Multiple Images of the Same Scene or Object(s)

Filing Date November 13, 1995
MIT Case Number 7113T
U.S. Patent Number 5,706,416
Issue Date January 6, 1998

Inventors Steve Mann, Rosalind Picard

Digitally encoded images having common subject matter are spatially related to one another and combined utilizing a projective coordinate transformation, the parameters of which are estimated featurelessly. For a given input image frame, the universe of possible changes in each image point consistent with the projective coordinate transformation is defined and used to find the projective-transformation parameters which, when applied to the input image, make it look most like a target image. The projective model correctly relates images of common (static) subject matter taken by a single camera at a fixed location, free to rotate about its center of projection (e.g., free to rotate about its optical axis, and to pan and tilt) and having a lens free to zoom; and planar scenes recorded by a camera free to move arbitrarily (including translation or other movements of the center of projection itself).

System Employing Dissipative Pseudorandom Dynamics for Communications and Measurement

Filing Date June 19, 1995
MIT Case Number 6781T
U.S. Patent Number 5,612,973
Issue Date March 18, 1997

Inventor Neil Gershenfeld

Linear feedback shift registers (LFSR) are routinely used as pseudorandom noise sources in spread spectrum systems to help satisfy many communication problems. Nonlinear chaotic systems have been applied to use entrainment to eliminate the problem of receiver acquisition and tracking, but they are not ideal noise sources. This invention generalizes the (mod) function used in an LFSR to a nonlinear continuous function with stable fixed points at the (mod) values, in order to provide dissipative exam-

entrainment along with optimal noise characteristics. An example is a suitably scaled and normalized (cos) function.

Layered Representation for Image Coding

Filing Date May 24, 1995
MIT Case Number 5763T
U.S. Patent Number 5,706,417
Issue Date January 6, 1998

Inventor Edward Adelson

This patent describes a moving image representation format and encoding and decoding techniques. In the format, the image is represented as a series of layers, each layer comprising one or more maps containing information about the image. In decoding the information, the maps are combined in an order dictated by their ordinal depth in the image. Each layer comprises (1) an intensity map representing the intensity of the pixels in that layer, (2) an attenuation map by which the image intensities of the layers below it are multiplied while the intensity map corresponding to its layer is multiplied by its complement, (3) a delta map that describes the temporal derivative of the points in the corresponding intensity map, and (4) a velocity map which describes how all points in the layer are warped over time.

Detection, Recognition and Coding of Complex Objects Using Probabilistic Eigenspace Analysis

Filing Date April 20, 1995
MIT Case Number 6567T
U.S. Patent Number 5,710,833
Issue Date January 20, 1998

Inventors Baback Moghaddam, Alex Pentland

Methods and apparatus for detecting instances of a selected object or object feature in a digitally represented scene utilize analysis of probability densities to determine whether an input image (or portion thereof) represents such an instance. The invention filters images of objects that, although in some ways similar to the object under study, fail to qualify as typical instances of that object. The invention is useful in the detection and recognition of virtually any multifeatured entity such as human faces, features thereof (e.g., eyes), as well as non-rigid and articulated objects such as human hands.

Method and System for Facilitating Wireless, Full-Body, Real-Time User Interaction with a Digitally Represented Visual Environment

Filing Date August 1, 1994
MIT Case Number 6773T
U.S. Patent Number 5,563,988
Issue Date October 8, 1996

Inventors Pattie Maes, Bruce Blumberg, Trevor Darrell, Thad Starner, Michael Johnson, Kenneth Russell, Alex Pentland

The cumbersome nature of the equipment and the limited nature of the interaction has so far limited the range of applications of virtual environments. The design and implementation of a novel system, called Alive, allows wireless full-body interaction between a human participant and a rich graphical world, inhabited by autonomous agents. Based on results obtained with real users, this kind of system can provide more complex and very different experiences from traditional virtual reality systems. The Alive system significantly broadens the range of potential applications of virtual reality systems, particularly in the areas of training and teaching, entertainment, and digital assistants or interface agents.

Method and Apparatus for Three-Dimensional, Textured Models from Plural Video Images

Filing Date January 18, 1994
MIT Case Number 6499T
U.S. Patent Number 5,511,153
Issue Date April 23, 1996

Inventors Ali Azarbayejani, Tinsley Galyean, Alex Pentland

We present a formulation for recursive recovery of motion, pointwise structure, and focal length from feature correspondences tracked through an image sequence. In addition to adding focal length to the state vector, several representational improvements are made over earlier structure from motion formulations, yielding a remarkably stable and accurate estimation framework which applies uniformly to both true perspective and orthographic projection. An extensive set of experimental

results using controlled synthetic input demonstrate the performance of the estimator under various noise levels and biases, under various degrees of initial condition uncertainty, under various extents of motion, and in a degenerate case. Additional experimental results using real imagery demonstrate the stability and accuracy of the estimator under conditions of real feature tracking.

System for Encoding Image Data into Multiple Layers Representing Regions of Coherent Motion and Associated Motion Parameters

Filing Date December 27, 1994
MIT Case Number 6262T C1
U.S. Patent Number 5,557,684
Issue Date September 17, 1996

Inventors John Wang, Edward Adelson

This patent application describes methods for representing video sequences as a set of layers, one moving over another. This representation, similar to that used in cel animation, can be applied to television sequences to allow efficient coding, special effects, and frame-rate conversion. We describe methods of motion analysis that achieve the decomposition. We perform local affine motion analysis and then do cluster analysis in affine parameter space to identify regions that are moving coherently. We then extract layers corresponding to these coherent motions. For example, in the MPEG flower garden sequence, a camera in a moving car views a tree in front of a flower garden. The moving tree forms one layer, the flower bed another layer, and so on. After the decomposition is performed it is possible to resynthesize the sequence from the components.

Method of Creating a High Resolution Still Image using a Plurality of Images and Apparatus for Practice of the Method

Filing Date October 30, 1992
MIT Case Number 5717T
U.S. Patent Number 5,657,402
Issue Date August 12, 1997

Inventors Walter Bender, Laura Teodosio

This invention relates to a method for creating a high resolution still image, using a plurality of images of varied focal length and an apparatus therefor. In particular, the invention relates to a method for creating a still high resolution, fixed focal length image, using a plurality of images of various focal lengths, such as a zoom video sequence. The invention also relates to creating a still panoramic image from a plurality of images of a field of view less than that of the still panoramic image.

Computer Method and Apparatus for Matching Between Line Drawings

Filing Date September 9, 1992
MIT Case Number 5831T
U.S. Patent Number 5,325,475
Issue Date June 28, 1994

Inventors Tomaso Poggio, Stephen Librande

Computer apparatus and method determines correspondence between two shapes or drawings. Included is a computer matcher which determines point by point matches/correspondence between a source object or drawing and a target object or drawing. As applied to the generation of animation sequences, the computer matcher is given as input a source drawing, a target drawing and at least four working points on the first drawing matched to four working points on the second drawing. The matcher defines a transform vector from the initially given working points of the first drawing and working points of the second drawing and their association. With the transform vector, the matcher performs a vector transformation of each of the remaining points on the first drawing to a respective point on the second drawing. This generates a correspondence and thus match between remaining points on the first drawing with respective remaining points on the second drawing. Additional processing with a ranking function provides a single match from possible multiple matches for each of

the remaining points on the first drawing with a respective remaining point on the second drawing. The ranking function also confirms matches made by the vector transformation.

Fractal-Based Image Compression and Interpolation

Filing Date October 10, 1991
MIT Case Number 5189T
U.S. Patent Number 5,148,497
Issue Date September 15, 1992

Inventors Alex Pentland, Eero Simoncelli, Thomas Stephenson

This technique, based on the use of a fractal mathematical model, may be used for image compression, enhancement, or restoration. On standard test images (256 x 256 eight-bit gray-scale images) the technique achieves compression ratios of 60-to-1 (0.12 bits-per-pixel) with approximately 40dB peak signal-to-noise ratio. For color or larger size images compression ratios are significantly higher.

Method and Apparatus for Electromagnetic Non-Contact Position Measurement with Respect to One or More Axes

Filing Date October 9, 1991
MIT Case Number 5677T
U.S. Patent Number 5,247,261
Issue Date September 21, 1993

Inventor Neil Gershenfeld

This invention offers a simple, robust and inexpensive solution to the problem of non-contact position measurement with respect to multiple (possibly non-linear) spatial axes. This information is retrieved by analyzing the RF propagation between flexible antennas fabricated from a very resistive thermoplastic. The method was developed to solve the problem of tracking the bow of the cellist Yo Yo Ma in order to interface him to computers in real-time during live performance, but it has obvious applications for problems such as machine-tool positioning or user interface sensing. The electromagnetic design of the sensors can easily scale from lengths of millimeters to tens or hundreds of meters.

Noise Reduction System

Filing Date September 24, 1991
MITCase Number 5684T
U.S. Patent Number 5,526,446
Issue Date June 11, 1996

Inventors Edward Adelson, William Freeman

We describe a new class of techniques to remove noise from images and to enhance their visual appearance. The general approach we describe is to (1) convert an image into a set of coefficients in a multi-scale image representation; (2) modify each coefficient based on its amplitude, and the amplitude of coefficients of related orientation, position, or scale; and (3) convert the modified coeffiecients back to a pixel representation to make the enhanced image.

Antialiasing Apparatus and Method for Computer Printers

Filing Date May 31, 1991
MIT Case Number 5651T
U.S. Patent Number 5,185,852
Issue Date February 9, 1993

Inventors V. Michael Bove, Jr., Christopher Mayer

Given a laser printer mechanism that permits the laser voltage to be modulated, this process enables the printer to accept a standard binary image and efficiently to produce an antialiased, grayscale print. To accomplish this, the printer uses a sliding window on the binary image as an address into a lookup table which outputs gray-scale pixel values. The process encompasses both the circuitry for accomplishing the antialiasing function, and the method of generating the contents of the lookup table.

Automobile Navigation System Using Real-Time Spoken Driving Instructions

Filing Date August 9, 1990
MIT Case Number 5088TS
U.S. Patent Number 5,177,685
Issue Date January 5, 1993

Inventors James Davis, Christopher Schmandt

An automobile navigation system which provides spoken instructions to the driver of an automobile to guide the driver along a route is disclosed. The heart of the system is a computing apparatus comprising a map database, route finding algorithms, a vehicle location system discourse generating programs, and speech generating programs. Driver input means allows the driver to enter information such as a desired destination. The route finding algorithms in the computer apparatus calculate a route to the destination. The vehicle location system accepts input from a position sensor which measures automobile movement (magnitude and direction) continuously, and using this data in conjunction with the map database, determines the position of the automobile. Based on the current position of the automobile and the route, the discourse generating program compose driving instructions and other messages according to a discourse model in real-time as they are needed. The instructions and messages are sent to a voice generating apparatus which conveys them to the driver.

Method and Facility for Dynamic Video Composition and Viewing

Filing Date February 9, 1990
MIT Case Number 5170T
U.S. Patent Number 5,101,364
Issue Date March 31, 1992

Inventors Glorianna Davenport, Hans Brondmo

A video composing and viewing facility and method that allows representation and arbitrary association of discrete image segments, both to create final compositions and to permit selective viewing of related segments is disclosed. The user represents an image segment by a single frame or series of frames that acts as a mnemonic reference. Information regarding image segments is retained in data structures that facilitate relational designations there among and sorting of image segments. Display of a segment may be interrupted and a new segment initiated on command, and provision maintained for return to the original segment when display of the new segment is completed.

Multiscale Coding of Images

Filing Date July 11, 1989
MIT Case Number 4789T
U.S. Patent Number 4,987,480
Issue Date January 22, 1991

Inventors Andrew Lippman, William Butera

This invention describes a complete video coder based on a combination of subband decomposition of the input sequence followed by vector quantization. The design of the subband's decomposition and subsequent coding are optimized for scalable decoding.

Media Lab U.S. Patents Transferred to Public Domain

(listed by filing date)

Finite-Element Method for Image Alignment and Morphing

Filing Date May 7, 1993
MIT Case Number 6160T
U.S. Patent Number 5,590,261
Issue Date December 31, 1996

Inventors Stanley Sclaroff, Alex Pentland

In a morphing system for creating intermediate images that, viewed serially, make an object in a source image appear to metamorphose into a different object in a target image, correspondences between feature points in the source and target images are determined by simulating the modes of motion of respective elastic sheets in which are embedded nodal points that correspond to respective feature points in the images. For each feature point, a generalized-feature vector is determined whose components represent the associated nodal point's participations in the various motion modes. Correspondences between feature points in the source and target images are determined in accordance with the closeness of the points' generalized feature vectors. Correspondences thus determined can additionally be used for alignment and object-recognition purposes.

Video Image Compositing Techniques

Filing Date June 4, 1992
MIT Case Number 5529T
U.S. Patent Number 5,262,856
Issue Date November 16, 1993

Inventors Andrew Lippman, Walter Bender, Patrick McLean, Henry Holtzman

One of the problems in using normal television images on HDTV sets is that the aspect ratio of HDTV is wider than that of a normal television set. This invention applies directly to the problem of widening the image for viewing on an HDTV system, or for any application where a widened image is desired. It also has advantages for compact coding and efficient transmission of the stored image. Using this method, actors and moving objects, together with a small surrounding area of background, are removed from the image. The images of the background set are then merged to capture detail from all angles, which creates a widened scene of the unmoving set objects. The moving objects are then reinserted into the picture. The areas of background that were clipped with the original images serve both to ensure proper placement and to eliminate the problem of blurry edges that occurs when actors are cut cleanly, ensuring that the resulting scene looks completely natural. A second effect of this method of image processing is that the coding is very efficient, since the detail of the background need only be transmitted once. Only the moving objects need to be transmitted repeatedly for reconstruction on the other end.

Face Recognition System

Filing Date November 1, 1990
MIT Case Number 5404T
U.S. Patent Number 5,164,992
Issue Date November 17, 1992

Inventors Matthew Turk, Alex Pentland

A recognition system for identifying members of an audience, the system including an imaging system which generates an image of the audience; a selector module for selecting a portion of the generated image; a detection means which analyzes the selected image portion to determine whether an image of a person is present; and a recognition module responsive to the detection means for determining whether a detected image of a person identified by the detection means resembles one of a reference set of images of individuals.

Optical Ranging Apparatus

Filing Date August 28, 1990
MIT Case Number 5222T
U.S. Patent Number 5,076,687
Issue Date December 31, 1991

Inventor Edward Adelson

This invention is a range camera that delivers a depth map of objects in a scene. It uses a single lens rather than the multiple lenses used in stereoscopic systems. The image falls on a lenticular array, which allows light entering through different parts of the lens to be separately analyzed. Image processing techniques allow one to determine how the image changes as the viewing position shifts left and right or up and down, and from this information the depth can be determined for each pixel. Only a single image from a single lens is required, and the image processing is quite simple. The system is compact and works best for examining small objects that are at short distances, such as one might encounter in manufacturing.

Method for Estimating Solutions to Finite Element Equations by Generating Pyramid Representations, Multiplying to Generate Weight Pyramids, and Collapsing the Weighted Pyramids

Filing Date August 21, 1990
MIT Case Number 5349T
U.S. Patent Number 5,287,529
Issue Date February 15, 1994

Inventor Alex Pentland

A new method is described for solving finite element method (FEM) and/or interpolation (lofting) problems with greatly reduced computational cost. This method uses wavelet functions to compute solutions to FEM and interpolation at a cost proportional to the number of nodes defining the problem, whereas previous solutions have a cost proportional to the square of the number of nodes. For large problems, therefore, this solution can be many orders of magnitude cheaper (or faster) than standard methods.

Three-Dimensional Display System

Filing Date April 12, 1990
MIT Case Number 4942T
U.S. Patent Number 5,172,251
Issue Date December 15, 1992

Inventors Stephen Benton, Joel Kollin

A three-dimensional display system includes a laser for generating a laser light signal. The signal is expanded and collimated using a traditional lens system and is directed to an acousto-optic modulator wherein it is modulated to generate a three dimensional image such as a holographic image. The modulation signal for the modulator is provided by a data processing system. The data processing system applies signals to the modulator that encode a diffraction pattern. The diffraction pattern is realized by the modulator upon application of the signals and the three-dimensional image is produced by the modulated light signals.The image is demagnified by a demagnifier, and subsequently, imaged by a viewing lens. A horizontal scanner continuously multiplexes segments of the holographic image and compensates for the motion of segments across the modulator. A vertical scanner is provided to properly vertically position horizontal lines of the holographic image.

Multidimensional Range Mapping with Pattern Project and Cross Correlation

Filing Date November 7, 1989
MIT Case Number 5025T
U.S. Patent Number 5,003,166
Issue Date March 26, 1997

Inventors Edward Adelson, William Butera

A range camera is provided for the determination of range to an object through the utilization of a system which projects a limited depth of field light pattern onto an object and measures the blurring of the pattern on the object. In one embodiment an anisotropic aperture or astigmatic optics are used in combination with an isotropic pattern to eliminate system error introduced by the camera. The anisotropic aperture provides that blurring takes place only in a given direction, with measurement of blurring in an orthogonal direction providing an output only responsive to the blurring associated with the camera. This blurring can then be subtracted out to eliminate system error from the range measurement. The range camera is operative to produce a range picture or map, with optional outputs providing localized albedo and a conventional brightness image. In another embodiment, the direction of the blur, either in front of or in back of the plane of best focus of the projected pattern, is provided through the utilization of astigmatic optics.

System for Ascertaining Direction of Blur in a Range-from-Defocus Camera

Filing Date November 7, 1989
MIT Case Number 5025T
U.S. Patent Number 4,965,442
Issue Date October 23, 1990

Inventors Bernd Girod, Edward Adelson

A range camera is provided for the determination of range to an object through the utilization of a system which projects a limited depth of field light pattern onto an object and measures the blurring of the pattern on the object. In one embodiment an anisotropic aperture or astigmatic optics are used in combination with an isotropic pattern to eliminate system error introduced by the camera. The anisotropic aperture provides that blurring takes place only in a given direction, with measurement of blurring in an orthogonal direction providing an output only responsive to the blurring associated with the camera. This blurring can then be subtracted out to eliminate system error from the range measurement. The range camera is operative to produce a range picture or map, with optional outputs providing localized albedo and a conventional brightness image. In another embodiment, the direction of the blur, either in front of or in back of the plane of best focus of the projected pattern, is provided through the utilization of a mask having an aperture devoid of point symmetry. In a further embodiment, direction of blur can be ascertained through the utilization of astigmatic optics.

Holographic Color Control Systems

Filing Date October 30, 1989
MIT Case Number 5040T
U.S. Patent Number 4,986,619
Issue Date January 22, 1991

Inventors Julie Walker, Stephen Benton

Holographic color control systems are disclosed for production of pseudocolor holograms by in-situ sequential swelling of an emulsion and exposure to three color separation images with a single wavelength reference light source. The resulting holograms yield images in three color primaries with excellent color registration and mixing, producing a full gamut of mixed colors, pastels and neutrals with three-dimensional perspective.

Method and Apparatus for Image Processing to Obtain Three-Dimensional Motion and Depth

Filing Date October 13, 1989
MIT Case Number 5156TS
U.S. Patent Number 4,980,762
Issue Date December 25, 1990

Inventors David Heeger, Allan Jepson

This patent describes an image processing system that extracts three-dimensional motion information from two-dimensional images. It allows recovery of the position, structure, and velocity of three-dimensional objects and recovery of camera motion. The method has been compared to the best previous systems and found to be much less sensi-tive to noise and measurement error, and therefore much more accurate. The system has potential applications in film and video production, in robotics, and in autonomous vehicle guidance.

Self-Contained Compact Multi-Color Edge-Lit Holographic Display

Filing Date August 9,1989
MIT Case Number 4901T
U.S. Patent Number 5,121,229
Issue Date June 9, 1992

Inventors Stephen Benton, Sabrina Birner

A three-step process is combined with an edge-lit system to provide a self-contained, maximally-compact holographic display. In one embodiment, a hologram is affixed to an upstanding transparent plate mounted through the top of a housing in which the hologram is edge-illuminated with white light from a source in the housing immediately beneath the plate to generate brilliant, sharp and deep multi-color images which straddle the hologram plane.

Video-Graphic Arthroscopy System

Filing Date July 27, 1989
MIT Case Number 4730T
U.S. Patent Number 5,005,559
Issue Date April 9, 1991

Inventors Ernesto Blanco, Pascal Chesnais, Phyllis Kristal, Andrew Lippman

A position sensing system which allows the arthroscopist to readily determine the location of an arthroscope's tip in relation to the point of entry has been developed. The position sensing apparatus can be employed in conjunction with a graphics module to display the location of the arthroscope in real-time and provide perspective views of the instrument's location.

Receiver-Compatible Enhanced Definition Television System

Filing Date February 2, 1989
MIT Case Number 4851T
U.S. Patent Number 5,010,405
Issue Date April 23, 1991

Inventors William Schreiber, Andrew Lippman, Edward Adelson, Aran Netravali

This patent describes a new method of adding information within an NTSC signal for the purpose of compatible improvement of image quality. The altered signal can be transmitted through a normal channel and appears on a standard receiver virtually unchanged, but on a special receiver the added information can be extracted and used for any desirable purpose. This includes improvement in spatial and/or temporal resolution, improvement in sound quality (for example by digital audio), stereo TV, a second TV channel, increase in image size, etc. The amount of information that can be added appears to be much larger than that of previously proposed methods. The added information does not make the signal more susceptible to channel degradation, although it does not actually improve the quality on NTSC receivers in the face of degradation. The enhancement information is relatively immune to channel degradation on the special receivers.

Extended Definition Television Systems

Filing Date January 12, 1989
MIT Case Number 4906T
U.S. Patent Number 5,003,377
Issue Date March 26, 1991

Inventors Andrew Lippman, Edward Adelson, William Butera

Methods and systems for adding additional information to broadcast motion picture signals so that an advanced receiver can decode that information to provide improved picture quality, while a standard receiver will display an image with minimally visible impairments. In particular, chrominance information can be generated at a fraction of the frame rate and the alternate frames then used to encode additional data, such as high definition luminance information in the chrominance signal.

Real Image Holographic Stereograms

Filing Date January 12, 1988
MIT Case Number 4509T
U.S. Patent Number 4,834,476
Issue Date May 30, 1989

Inventor Stephen Benton

Methods and devices for recording and projecting holographic stereograms are disclosed. In one aspect of the invention, a concave semi-cylindrical ("alcove") display system is disclosed in which an image is projected in front of the alcove. The display system provides a very wide angle of view approaching 180 degrees (compared to the 30 degrees of a typical flat hologram) that allows the viewer to look around most of the image content. This type of display is particularly useful in computer aided design projects where designers wish to present an overall three-dimensional display of their work. In another aspect of the invention, a holographic printer and procedures for recording a stereogram are disclosed as well as techniques for producing "predistorted" images for the sub-holograms. A digital processing technique is disclosed which effectively predistorts the source two-dimensional image set for the stereogram to compensate for the effects of the display geometry. This predistortion technique relies upon anamorphic ray tracing. A crossed slit model for the holograhic optical system is used to determine the direction and origin of the rays of light from which each sub-hologram of the stereogram is made.

Unrecordable Video Signals

Filing Date March 23, 1984
MIT Case Number 3858T
U.S. Patent Number 4,673,981
Issue Date June 16, 1987

Inventors Andrew Lippman, V. Michael Bove, Jr., Jerome Wiesner

This patent describes a technique for handling video signals so as to permit such signals to be satisfactorily displayed on video display devices, such as TV receivers or monitors, but to prevent such signals from being satisfactorily recorded by video recording devices. In a particular embodiment thereof the video frame time base is altered in a selected manner, as by lengthening or shortening the time bases of successive video frames, or successive groups of video frames. The alterations thereof can be in discrete steps and be performed cyclically so that during each overall cyclical time period the cumulative error is zero.