AN ANNOTATED BIBLIOGRAPHY FOR DISTRIBUTED DYNAMIC SCENE ANALYSIS

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This annotated bibliography is the result of Mr. Tan's dissertation research, entitled "Distributed Processing for Multiresolution Dynamic Scene Analysis". References describing the work of that dissertation are included in this bibliography as [Tan85a], [Tan85b], [Tan86a], [Tan86b], and [Tan86c].

The above research was supported in part by the NSF Grant No. EC-83-07248. Mr. Tan is supported by the National University of Singapore through an overseas graduate scholarship.

[Alle84] Allen J.F., "Towards a general theory of action and time," Artificial Intelligence 23 (1984), pp. 123-154.

A temporal logic is presented in this paper for handling temporal aspects of events and actions in generating a plan.

[Agga75] Aggarwal, J.K. and R.D. Duda, "Computer analysis of moving polygonal images," IEEE Trans. Computer, Vol. C-24, pp. 966-976, Oct. 1975.

An idealized mathematical model is developed which consists of superimposed planes of rigid moving polygons. The problem is to determine from a sequence of scenes the linear and angular velocities of the polygons and to decompose the scene into its component figures.

[Agga81] Aggarwal J.K., L.S. Davis and W.N. Martin, "Correspondence processes in dynamic scene analysis," Proceedings of IEEE, Vol. 69, No. 5, pp. 562-572, 1981.

Two approaches to establishing correspondences are discussed. One uses iconic models while the other is based on structural matching.

[Agga83] Aggarwal, J.K. and W.N. Martin, "Dynamic scene analysis," in [Huan83], pp. 40-73, 1983.

Three major components of dynamic scene analysis, namely segmentation, occlusion and the computation of 3-D information from images are discussed in depth.

[Agga84] Aggarwal, J.K., "Motion and time-varying imagery," Computer Graphics, Vol. 18, No. 1, pp. 20-21, Jan. 1984.

A brief history of dynamic scene analysis is given followed by a synopsis of four papers on motion presented in the SIGGRAPH/SIGART Interdisciplinary workshop on Motion, Toronto, April, 1983.

[Agra82] Agrawal, D.P. and R. Jain, "A pipelined pseudoparallel system architecture for real-time dynamic scene analysis," IEEE Trans. Computers, Vol. C-31, No. 10, pp. 952-962, 1982.

The authors introduce the concept of pseudoparallelism in which an motion analysis algorithm (based on differencing techniques) is partitioned into several noninteractive independent subtasks so that parallelism can be used within each subtask level. The pseudoparallel model is a combination of SIMD/MIMD/pipelined structures.

[Anto81] Antonsson D., P.-E. Danielsson, B. Gudmundsson, T. Hedblom, B. Kruse, A. Linge, P. Lond and T. Ohlsson, "PICAP - a system approach to image processing," IEEE Workshop on Computer Architecture for Pattern Analysis and Image Database Management, Hot Springs, VA., pp. 35-42, Nov. 1981.

PICAP II described in this paper is a bus-structured multiprocessor that allows 15 processors, some of which are SIMD array processors, to be connected under the coordination of a host computer SEL 77/35.

PICAP II has been applied mainly in image processing research.

[Arki75] Arking, A.A., R.C. Lo and A. Rosenfeld, "An evaluation of fourier transform techniques for cloud motion estimation," Computer Science Technical Report TR-242, University of Maryland, 1973.

This report summarizes a number of papers on the use of two Fourier transform techniques to estimate cloud motions from a pair of successive frames. The first technique uses cross-correlation while the second is a phase shift analysis.

[Bajc80] Bajcsy R. and D.A. Rosenthal, "Visual and conceptual focus of attention," in [Tani80a], pp. 133-149, 1980.

Visual hierarchies for low-level processing and conceptual hierarchies for high-level processing are introduced and discussed.

[Ball82] Ballard, D. and C.M. Brown, *Computer Vision*, Prentice-Hall, Inc., 1982.

Four parts: (1) Generalized images, (2) Segmented images, (3) Geometrical structures, and (4) Relational structures. 13 chapters, 523 pages.

[Basi83] Basille, J.-L., S. Castan and M. Al Rozz, "Parallel architectures adapted to image processing, their their limits," in [Duff83], pp. 31-42, 1983.

Different types of parallel architectures are compared with emphasis given to the MIMD structures for which a performance analysis is given.

[Bask76] Baskett, F. and A.J. Smith, "Interference in multiprocessor computer systems with interleaved memory," Comm. ACM, Vol. 19, No. 6, pp. 327-334, 1976.

This paper analyzes the memory interference caused by several processors simultaneously using several memory modules. A simple model of such a system is constructed with the limiting value derived for the relative degree of memory interference as the system size increases.

[Barn80] Barnard, S.T. and W.B. Thompson, "Disparity analysis of images," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-2, No. 4, pp. 333-340, 1980.

Feature points are first extracted form two images. Disparities between candidate points are iteratively estimated using a relaxation labeling technique. These disparities provide a good measure for object motion and binocular parallax.

[Barr78] Barrow, H.G. and J.M. Tenenbaum, "Recovering intrinsic scene characteristics from images," in [Hans78a], pp. 3-26, 1978.

A model for extracting intrinsic characteristics (e.g. range, orientation, reflectance, incident illumination) is described. The model is partly motivated by the apparent ability of humans to determine these characteristics regardless of viewing conditions or familiarity with the

scene.

[Beck83] Beck, J., B. Hope and A. Rosenfeld, eds., *Human and Machine Vision*, Academic Press, 1983.

This book is based on a conference in August 81. The conference brought together psychologists and computer scientists interested in visual perception.

[Berg83] Bergmann, H.C., "Analysis of different displacement estimation algorithms for digital television signals," in [Huan83], pp. 213-234, 1983.

This paper surveys several methods for displacement estimation in television scenes, including that of Limb and Murphy [Limb75], Cafforio and Rocca [Caff83], and Netravali and Robbins [Robb83].

[Bers83] Bers, K.-H., M. Bohner, P. Fritsche, "Image sequence analysis for target tracking," in [Huan83], pp. 493-501, 1983.

A system combining correlation and object detection methods is described. The object to be tracked is mainly located by correlation between the actual scene and a reference. Object detection method is then used to assist in finding the final object position.

[Bout83] Bouthemy, P. and A. Benveniste, "Atmospheric disturbances tracking in satellite images," in [Huan83], pp. 580-593, 1983.

A gradient algorithm based on a so-called 'spirals model' is used in identifying atmospheric disturbances from a sequence of satellite images.

[Blan85] Blanc, G.E. and W.N. Martin, "Visual monitoring of autonomous life sciences experimentation," Proceedings of SPIE, Vol. 580, Space Station Automation, Cambridge, Massachusetts, Sept. 17-18, 1985.

A vision system to monitor and control life sciences experimentation on board space stations is proposed. The system is organized as a multi-processor system with distributed processes selectively analyzing hierarchical imagery.

[Brad83a] Brady, M., "Parallelism in vision," Artificial Intelligence, Vol. 21, pp. 271-283, 1983.

Parallel image processing hardware and applications in robot vision are discussed. The paper also contains a list of current image analysis machines and an annotated bibliography.

[Brad83b] Braddick, O.J. and A.C. Sleigh, eds., *Physical and Biological Processing of Images*, Proceedings of an International Symposium, London, England, 27-29 Sept. 1982.

This book consists of papers presented at the above symposium. The papers are grouped under the following headings: (1) overviews, (2) local spatial operations on the image, (3) early stages of image interpretation, (4) pattern recognition, (5) spatially analog processes, (6)

higher level representations in image processing. 27 papers. 403 pages.

[Brau83] Braunstein, M.L., "Contrasts between human and machine vision: should technology recapitulate phylogeny," in [Beck83], pp. 85-96, 1983.

Special constraints on the biological visual system were discussed by considering its three characteristics: the primacy of depth perception, the coexistence of perception and contradictory knowledge, and the use of heuristic perceptual processes. The author argues that while these constraints are necessary for survival, they need not be exploited in machine vision.

[Brig82] Brigg, F.A., K.-S. Fu, K. Hwang and B.W. Wah, "PUMPS architecture for pattern analysis and image database management," IEEE Trans. Computers, Vol. C-31, No. 10, pp. 969-983, 1982.

The PUMPS architecture consists of several task processing units (TPU) which share a pool of special peripheral processors, VLSI functional units, and a common shared memory via a interconnection network. The shared memory is also connected to the file memories via a backend image database management. VLSI functional units permit pattern analysis and recognition of context-free languages and finit-state languages.

[Bull78] Bullock, B.L., "The necessity for a theory of specialized vision," in [Hans78a], pp. 27-35, 1978.

A re-usable vision system is presented. This system is specialized but can be made extensible through the use of GPMs (general-purpose models) and re-usable through the use of knowledge-based reconfiguration.

[Burt83] Burt, P.J., C. Yen and X. Xu, "Mult-resolution flow-through motion analysis," IEEE Conf. on Computer Vision & Pattern Recognition, pp. 246-252, 1983.

A four stage approach to motion analysis is proposed, in which (1) images are decomposed into spatial frequency bands, (2) a set of direction and velocity "channels" are formed within each band, (3) the output of these channels are combined into orientation channels, and (4) an optical flow field is formed for each frequency band. The above stages may be done in parallel pipelined hardware.

[Burt84] Burt, P.J., "The pyramid as a structure for efficient computation," in [Rose84a], pp. 6-35, 1984.

The construction of Gaussian (low-pass filter) pyramids and Laplacian (Bandpass filter) pyramids and other pyramid operations are described. The paper also describes a correlation approach to motion analysis in which pyramid procedures are used to minimize the cost of computation.

[Caff83] Cafforio, C. and F. Rocca, "The differential method for image motion estimation," in [Huan83], pp. 104-124, 1983.

Motion is estimated by comparing frame differences with the spatial variations of the luminance, as described in this paper. A linear

regression approach is used which is based on the first-order terms in the Taylor series expansion.

[Camm83] Cammarata S., D. MacArthur and R. Steeb, "Strategies of cooperation in distributed problem solving," Proc. 8IJCAI, pp. 767-770, 1983.

This paper describes four strategies for cooperation in the context of an air-traffic control system. These strategies differ in how an agent (each associated with an aircraft) is selected to modify its own plan to resolve conflict while the remaining agents perform no actions.

[Cant83] Cantoni, V., C. Guerra and S. Levialdi, "Towards an evaluation of an image processing system," in [Duff83], pp. 43-56, 1983.

Performances for different image operations (local operations, histograms, 2D transforms, etc.) among four different architectures (Von Neumann, SIMD, pipeline and paracomputer) are compared and contrasted.

[Chan77] Chang, D.Y., D.J. Kuck and D.H. Lawrie, "On the effective bandwidth of parallel memories," IEEE Trans. Computers, Vol. C-26, pp. 480-489, 1977.

Several models of interleaved or parallel memory systems are presented. The underlying assumptions about the address streams in each model and the performance of each model are discussed.

[Chow77] Chow, W.K. and J.K. Aggarwal, "Computer analysis of planar curvilinear moving images," IEEE Trans. Computers, Vol. C-26, pp. 179-185, 1977.

Object descriptors are used for matching in tracking moving planar objects, as proposed in this paper. Occlusion is resolved by using a predictive model.

[Cohe82a] Cohen, P.R. and E.A. Feigenbaum, eds., *The Handbook of Artificial Intelligence*, Vol. III, HeurisTech Press, Chapter XIII, Section E1, "pyramids and quad trees," pp. 279-282, 1982.

Definition and applications of pyramids and quad trees are briefly given in this section.

[Cohe82b] Cohen, P.R. and E.A. Feigenbaum, eds., *The Handbook of Artificial Intelligence*, Vol. III, HeurisTech Press, Chapter XI, Section C, "Opportunistic problem solving," pp. 22-27.

This section discusses the planning theory developed in [Haye80]. The theory is specifically of human planning which is opportunistic in nature.

[Cork79] Corkill, D.D., "Hierarchical planning a distributed environment," Proc. 6IJCAI, Japan, pp. 168-175, 1979.

A distributed implementation of NOAH [Cohe82b] is proposed as a

generalization to a distributed planning system.

[Cork83] Corkill D.D. and V.R. Lesser, "The use of meta-level control for coordination in a distributed problem solving network," Proc. 8IJCAI, 1983. pp. 748-756.

An organizational structure is used to provide each node with a high-level view of problem solving in the network. While this organization structure is constructed and maintained, there is a continuous local elaboration of this structure into precise activities using the local control capabilities of each node.

[Dani81] Danielsson, P.-E. and S. Levialdi, "Computer architectures for pictorial information systems," IEEE Computer, Vol. 14, No. 11, pp. 53-67, 1981.

This is an excellent survey of parallel architectures for image processing. The authors categorize various machines according to the four dimensions of parallelism: operator, image, neighborhood, and pixel-bit.

[Davi83] Davies, E.R., "Image processing - its milieu, its nature, and constraints on the design of special architectures for its implementation," in [Duff83], pp. 57-76, 1983.

Parallel architectures are discussed in the light of Danielsson and Levialdi's definition of four dimensions of parallelism [Dani81].

[Doug80] Douglass, R.L., "The requirements of a language for asynchronous parallel image processing," IEEE International Conference on Parallel Processing, pp. 147-148, 1980.

The characteristics of a parallel language for image processing are discussed as part of the design considerations in the PISCES [Prat84] project.

[Duff81] Duff, M.J.B. and S. Levialdi, eds., *Languages and Architectures for Image Processing*, Academic Press, 1981.

This is a collection of papers from two workshops. The first half concerns with languages, proceeding from the general to the particular. In the second half, the trend is from machines with few processors to machines with many processors. 26 papers. 327 pages.

[Duff83] Duff, M.J.B., ed., *Computing Structures for Image Processing*, Academic Press, 1983.

The book contains a collection of papers from four workshops. Parallel architectures and algorithms are the main issues discussed in these papers. 13 papers. 214 pages.

[Dyer81] Dyer, C.R., "A VLSI pyramid machine for hierarchical parallel image processing," IEEE Conf. Pattern Recognition and Image Processing, pp. 381-386, Aug. 1981.

Several possible VLSI designs of pyramid machines are given in this paper, taking into account both the advancing technology constraints

and the processor communications required in pyramid algorithms.

[Endl71] Endlich, R.M., D.E. Wolf, D.J. Hall and A.E. Brian, "Use of a pattern recognition technique for determining cloud motions from sequences of satellite photographs," J. Appl. Meteorol., Vol. 10, pp. 105-117, 1971.

A pattern recognition technique known as ISODATA is used to find brightness centers of individual clouds. Cloud motions are then derived by matching brightness centers on two satellite pictures.

[Ensl77] Enslow, P.H., "Multiprocessor organization - a survey," Computing Surveys, Vol. 9, No. 1, pp. 103-129, 1977.

Three types of interconnection are first discussed. They are (1) time-shared buses, (2) crossbar switch matrix, and (3) multibus, multiport memories. This is followed by a discussion on three multiprocessor operating systems: (1) master-slave, (2) individual executives, and (3) "floating" master.

[Erma78] Erman, L.D. and V.R. Lesser, "System engineering techniques for artificial intelligence systems," in [Hans78a], pp. 37-45, 1978.

Design principles and some implementation issues in Hearsay-II are discussed.

[Erma80] Erman, L.D., F. Hayes-Roth, V.R. Lesser and D.R. Reddy, "The hearsay-II speech-understanding system: integrating knowledge to resolve uncertainty," Computing Surveys, Vol. 12, No. 2, pp. 213-253, Jun. 1980.

This paper describes the working of the Hearsay-II system with a detailed example. Comparison with HARPY, HWIM and SDC is also made.

[Faug83] Faugeras, O.D., ed., *Fundamentals in Computer Vision*, Cambridge University Press, 1983.

This book contains materials for an advanced course in computer vision. There are 6 sections: (1) preprocessing, (2) feature extraction, (3) segmentation, (4) shape, (5) control and knowledge representation, and (6) hardware and software. 28 papers. 498 pages.

[Ferr82] Ferrie, F.P., M.D. Levine and S.W. Zucker, "Cell tracking: A modeling and minimization approach," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-4, pp. 277-291, 1982.

The model presented here includes a representation for cell dynamics enabling the system to maintain a correspondence between successive images of cells under going morphological changes. The correspondence is established by minimizing differences between a hypothesized instance and the last instance of a cell.

[Fenn77] Fennell R.D. and V.R. Lesser, "Parallelism in artificial intelligence problem solving: a case study of hearsay II," IEEE Trans. Computers, C-26, Feb. 77, pp. 98-111.

Issues in parallel implementation of hearsay II are discussed. A simulation model is also described with some results presented.

[Fenn79] Fennema C.L. and W.B. Thompson, "Velocity determination in scenes containing several moving objects," Computer Graphics & Image Processing, Vol. 9, pp. 301-315, 1979.

A spatial gradient method using a modified Hough transform clustering approach is described. The method can handle occlusion, works on blurred images, can determine the velocity magnitude within about 1 pixel/frame.

[Fike71] Fikes, R.E. and N.J. Nilsson, "STRIPS: a new approach to the application of theorem proving to problem solving," Artificial Intelligence, Vol. 2, pp. 189-208, 1971.

STRIPS represents a world model as an arbitrary collection of first order predicate calculus formulae. It employs a resolution theorem prover to answer questions of particular models and uses means-ends analysis to guide it to the desired goal-satisfying model.

[Fike72] Fikes, R.E., *et al.*, "Some new directions in robot problem solving," in *Machine Intelligence*, Vol. 7, B. Meltzer and D. Michie, eds., New York, Wiley, 1972.

The new directions in robot problem solving discussed in this paper include multiple goals, dynamic environments, hierarchical level actions, indeterministic outcome, and multiple robot systems.

[Fisc78] Fischler, M.A., "On the representation of natural scenes," in [Hans78a], pp. 47-52, 1978.

The author stresses the need for isomorphic/iconic representation in natural scene analysis.

[Fitz85] Fitzgerald, N.J., *A Parallel Programming Environment*, M.S. Thesis, C.S. Dept., University of Virginia, May, 1985.

Two implementations of PISCES [Prat84], one on a VAX under UNIX and the other on an Apollo network, are described in this thesis.

[Flyn66] Flynn, M.J., "Very high speed computing systems," Proc. IEEE, Vol. 54, pp. 1901-1909, Dec. 1966.

The classical paper of Flynn's classification of computer systems: SISD, SIMD, MISD, and MIMD.

[Foun81] Fountain, T.J., "CLIP4: A progress report," in [Duff81], pp. 283-291, 1981.

CLIP4 contains an array of 96×96 bit-slice PEs, with eight neighbors per PE. CLIP4 allows window and neighborhood operations for bit-plan image processing and feature extraction.

[Foun83] Fountain, T.J., "A survey of bit-serial array processor circuits," in [Duff83], pp. 1-14, 1983.

The following bit-serial array processors for image processing are surveyed and compared: CLIP4, MPP, NTT, DAP, PCLIP, CLIP5, GRID, and LPP.

[Fox81] Fox, M.S., "An organizational view of distributed systems," IEEE Trans. Systems, Man & Cybernetics, Vol. SMC-11, No. 1, pp. 70-81, 1981.

The Hearsay-II and its distributed version are compared to human organizations. Theories germane to the management science can be applied to distributed systems.

[Free74] Freeman, H., "Computer processing of line drawing images," Computer Survey, Vol. 6, No. 1, pp. 57-98, Mar. 1974.

Describes various forms of line drawing representations, compares different schemes of quantization and reviews the manner in which a line drawing can be extracted from a tracing or a photographic image. Different encoding schemes are compared. The properties of chain-coded line drawings are derived.

[Gemm81] Gemmar, P., H. Ischen and K. Luetjen, "FLIP: a multiprocessor system for image processing," in [Duff81], pp. 245-256, 1981.

FLIP is an MIMD system which contains 16 processors in one of its module FIP (Flexible Individual Processors). FLIP is able to perform up to 64 MIPS and takes about one second to perform most of the considered image processing tasks on images with 512×512 pixels.

[Genn79] Gennery, D.B., "Object detection and measurement using stereo vision," Proc. 6IJCAI, pp. 320-327, 1979.

Object detection using stereo vision data for obstacle avoidance and navigation in an exploring vehicle is described. Objects are approximated by ellipsoids. Segmentation of the objects is done by clustering points above the ground and fitting ellipsoids to match these clusters.

[Gerr83] Gerritsen, F.A., "A comparison of the CLIP4, DAP, and MPP processor-array implementations," in [Duff83], pp. 15-30, 1983.

Comparison of the three implementations with regard to their array architectures, performances, etc are given in this paper.

[Gibs68] Gibson, J.J., "What gives rise to the perception of motion," Psychology Rev., Vol. 75, No. 4, pp. 335-346, 1968.

The assumption that displacement of retinal image over the retina is the basis for all perception of motion is rejected. Another theory of the information for perceiving motion is proposed in terms of the ambient array of light.

[Gilb80] Gilbert, A.L., M.G. Giles, G.M. Flachs, R.B. Rogers, and Y.H. U, "A real-time video tracking system," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-2, No. 1, pp. 47-56, 1980.

This paper describes a system for missile and aircraft tracking. The system contains a video processor, projection processor, tracking

processor and control processor, that perform identifying, positioning, tracking and controlling respectively.

[Gilb81] Gilbert, A.L., "Video data conversion and real-time tracking," IEEE Computer, Vol. 14, No. 8, pp. 50-56, 1981.

The RTV system described here is explained in greater detail in [Gilb80].

[Gior81] Giordana A. and L. Saitta, "A distributed knowledge representation for real world analysis," Proc. Int. Conf. Cybernetics & Society, Oct. 1981. pp. 133-138.

A methodology for representing knowledge in a system oriented to real world data analysis (vision, speech, etc) is described. A hierarchical network of elementary knowledge sources is presented.

[Glaz83] Glazer, F., G. Reynolds and A. Anandan, "Scene matching by hierarchical corporation," IEEE Conference on Computer Vision & Pattern Recognition, pp. 432-441, Jun. 1983.

Hierarchical correlation using processing cones described in this paper is similar to that in [Wong78]. Displacement vectors are here obtained in a 3 by 3 search strategy. A cost reduction factor of 352 (for a maximum displacement of 32 pixels at the finest level) is reported.

[Grae83] Graefe, V., "A pre-processor for the real-time interpretation of dynamic scenes," in [Huan83], pp. 517-531, 1983.

The design and implementation of a preprocessor that reduces the amount of data to be processed by a master computer is described in this paper. The preprocessor contains several picture processors, all having parallel access to the digitized video signal, with each processor working on a small window. The system is tested in an experiment involving balancing an inverted pendulum.

[Gran81] Granlund, G.H., "GOP: a fast and flexible processor for image analysis," in [Duff81], pp. 179-188, 1981.

The GOP (General Operator Processor) described here contains four arithmetic pipelines and have been used in such image operations as filtering, edge detection, texture description, segmentation, relaxation and classification.

[Grea75] Greaves, J.O.B., "The bugsystem: the software structure for the reduction of quantized video data of moving organisms," Proc. IEEE, Vol. 63, No. 10, pp. 1415-1425, Oct. 1975.

The movements of organisms in a wet-slide preparation is recorded on video tape with the aid of a microscope. Binary pictures are then obtained by interactive thresholding and each organism is thinned to a single point. Sequences of point are evaluated to aggregate parameters like velocity and mean direction.

[Grin83] Grinaker, S., "Real-time processing of rasterscan images," in [Huan83], pp. 550-562, 1983.

A parallel-pipeline architecture is proposed which permits image processing while raster-scanning. The configuration is however restricted to local operations. For global processing, image storing (to enable multiple passes) or some heuristic prediction based on preceding images will be necessary.

[Gros84] Grosky, W.I. and R. Jain, "Region matching in pyramids for dynamic scene analysis," in [Rose84a], pp. 331-342, 1984.

A computational algorithm for extracting regions at different levels of a pyramid is proposed. These regions are used in hierarchical matching in dynamic scene analysis.

[Guid81] Guida G. and M. Somalvico, "Multi-problem solving: knowledge representation and system architecture," Information Processing Letters, Vol. 13, No. 4,5, pp. 204-214, 1981.

A model of multi-problem solving is described in terms of its basic architecture, knowledge representation, strategies and mode of operation, etc.

[Haas81] Haass, U.L., *Cloud Tracking from Satellite Pictures*, Ph.D. Dissertation, E.E. Dept., Colorado State University, 1981.

Several methods of cloud motion analysis are introduced based on different signal characterizations and various degrees of image abstraction. These include computation of the maximum of inner product surface, tracing and re-sampling of closed contour of the cloud, and parameter modelling and forecasting by a Kalman filter. 128 pages.

[Hans78a] Hanson, A.R. and E.M. Riseman, eds., *Computer Vision Systems*, Academic Press, 1978.

This book contains 26 papers presented in a 1977 workshop. These papers are grouped under the following headings: Issues and Research Strategies; Segmentation; Theory and Psychology; and Systems.

[Hans78b] Hanson, A.R. and E.M. Riseman, "Defining the field of computer vision," in [Hans78a], pp. xv-xvii, 1978.

This is an introductory paper to the workshop on Computer Vision Systems. Three levels of vision are discussed.

[Hans78c] Hanson, A.R. and E.M. Riseman, "VISIONS: a computer system for interpreting scenes," in [Hans78a], pp. 303-333, 1978.

This paper describes the design of a general system for interpreting static natural scenes. The system contains a short-term memory representing an interpretation of a specific image and a long-term memory representing general visual knowledge of the world. A set of knowledge sources together with a control and search scheme guide the interpretation process.

[Hans80] Hanson A.R. and E.M. Riseman, "Processing cones: a computational structure for image analysis," in [Tani80a], pp. 101-131, 1980.

Three basic processing modes (reduction, lateral, and projection) with cone algorithms are first presented, followed by an edge detection example and a discussion of operating system issues.

[Hart78] Hartley, M.G., R.C. Waterfall and A.J. Fisher, "Preliminary studies into the CAD of pedestrian circulation areas," Universities Transport Study Group, Nineth Annual Conf., City University, London, pp. 693-700, Jan. 1978.

Since sufficiently detailed data on pedestrian behavior is scarce, the primary aim of the project was to mechanize the acquisition of such data. This is achieved by computer analysis of pictures from a TV camera mounted in a corridor ceiling.

[Hart84a] Hartley, R., "A gaussian-weighted multi-resolution edge detector," Technical Report No. CAR-TR-72, Center for Automation Research, University of Maryland, Jul. 1984.

An edge operator is developed which weights the neighborhood of a point according to a Gaussian function. A pyramid structure allows an efficient implementation of the operation in which versions of the operator with various different neighbor sizes are applied to an image simultaneously.

[Hart84b] Hartley, R., "Segmentation of optical flow fields by pyramid linking," Technical Report No. CAR-TR-86, Center for Automation Research, University of Maryland, Aug. 1984.

Each node in the pyramid structure used here contains optical flow information. The initial overlapped linking (with each child connected to four fathers) is iteratively pruned until each node is linked to one father. The final pyramid linking forms a tree with the node at a particular level representing segments of optical flow fields.

[Haye80] Hayes-Roth, B., "human planning processes," Rep. No. R-2670-ONR, Rand Corp., Santa Monica, CA, 1980.

The paper formulates an opportunistic planning model which views planning as the cooperative efforts of many independent plan specialists or condition-action rules. Each specialist makes tentative decisions for incorporation into the developing plan and ports them in a common data structure - the blackboard.

[Haye83] Hayes-Roth B. , "The blackboard architecture: A general framework for problem solving?" Heuristic Programming Project Report HPP-83-30, Stanford University, 1983.

This paper defines the blackboard architecture's basic components: entries, knowledge sources, the blackboard, and the control mechanism. It enumerates the basic assumptions underlying these components and shows how they give the architecture computational advantages, psychological plausibility, and general scientific merit.

[Haye84] Hayes-Roth B., "A blackboard model of control," Heuristic Programming Project Report HPP-83-38, Stanford University, 1984.

This paper proposes a blackboard model of control and shows how it achieves the seven behavioral goals that are required to solve the control problem intelligently.

[Haye85] Hayes-Roth B., "Learning control heuristics in BB1," Programming Project Report HPP-85-2, Stanford University, 1985.

A blackboard system building architecture, BB1, is described. Learning knowledge sources in the architecture, by interacting with the expert, update existing or create new control heuristics.

[Hend73] Hendrix, G.G., "Modeling simultaneous actions and continuous processes," Artificial Intelligence, Vol. 4, pp. 145-180, 1973.

A methodology is here developed that models temporal elements of processes (e.g. simultaneity, gradual changes, continuity). Considerable attention is given to applications in robotics.

[Hild83] Hildreth, E.C., *The Measurement of Visual Motion* MIT Press, 1983.

This book examines the measurements of motion and the use of relative movement to locate the boundaries of physical objects in the environment. It investigates the nature of the computations that are necessary to perform this analysis by any vision system, biological or machine.

[Horn81] Horn, B.K.P. and B.G. Schunck, "Determining optical flow," Artificial Intelligence, Vol. 17, pp. 185-203, 1981.

An iterative algorithm for determining velocity vectors based on a spatial temporal gradient method is presented. The type of motion considered here is a simple continuous translation across the image plane.

[Hohn83] Hohne, K.H. and M. Bohm, "Processing and analysis of radiographic image sequences," in [Huan83], pp. 602-623, 1983.

Processing of x-ray image sequences for studying blood flow and heart motion is discussed in this paper. Techniques such as intravenous angiography, angiocardiography, cinedensitometry are described.

[Huan83] Huang, T.S., ed., *Image Sequence Processing and dynamic scene analysis*, Springer-Verlag, 1983.

This is the proceedings of the NATO Advanced Study Institute held in June/July, 1982, Braunlage/Harz, Federal Republic of Germany. The book contains 4 parts: (1) Overview, (2) Image sequence coding, (3) Scene analysis and industrial applications, and (4) Biomedical applications. 38 papers. 749 pages.

[Hunt81] Hunt, D.J., "The ICL DAP and its application to image processing," in [Duff81], pp. 273-282, 1981.

DAP has an array of 64×64 processors each with a 4K 1-bit memory.

Each processor has a data connection to its four nearest neighbors.

[Hwan83] Hwang, K and K.-S. Fu, "Integrated computer architectures for image processing and database management," IEEE Computers, Vol. 16, No. 1, pp. 51-60, 1983.

A number of existing architectures for parallel image processing (e.g. Illiac-IV, CLIP4, MPP, Cytocomputer, PICAP II, ZMOB, etc.) and software packages for image database management are surveyed.

[Ibra84] Ibrahim, H.A., "Image understanding algorithms on fine-grained tree-structured SIMD machines," Doctoral dissertation, Columbia University, 1984.

The author develops several parallel image understanding algorithms for the NON-VON supercomputer currently under construction at Columbia University. The NON-VON machine is a hierarchical machine but uses a binary tree structure, quite different from the conventional pyramid or quad structure.

[IEEE85] IEEE, "Minis and Mainframes," in *Technology '85*, ed. by the staff of IEEE *SPECTRUM*, pp. 42-44, 1985.

Among other things, a number of parallel computers for image recognition are described in this article.

[IFS81] IFS (Conference) Ltd., Proceedings of the 1st International Conference on Robot Vision and Sensory Controls, Kempston, Bedford, England, Apr. 1981.

The following topics were dealt with: image processing, visual inspection, navigation, mobile robots, force transducers, adaptive controls, optis, pattern recognition, multiprocessor system, tactile sensing, identification, 3-D vision, and scene analysis. 34 papers. 347 pages.

[Jaco80] Jacobus, C.J., R.T. Chien and J.M. Selander, "Motion detection and analysis of matching graphs of intermediate-level primitives," IEEE Trans. Pattern Analysis & Machine Intell., Vol. PAMI-2, No. 6, pp. 495-510, 1980.

Structural information (such as contour curvatures, vertices, intensity variations) are extracted and represented in the form of graphs. A graph matching system is used to established correspondences.

[Jain79] Jain, R., W.N. Martin and J.K. Aggarwal, "Segmentation through the detection of changes due to motion," Computer Graphics & Image Processing, Vol. 11, pp. 13-34, 1979.

Differencing techniques are used to identify areas containing moving objects. The images of the moving objects can then be obtained by focusing the segmentation processes on these restricted areas.

[Jain81a] Jain, R., "Dynamic scene analysis using pixel-based processes," IEEE Computer, Vol. 14, No. 8, pp. 12-18, 1981.

Motion detection based on difference pictures is explained. A decision tree is used that identifies various kinds of regions in the different pictures and hence types of motion.

[Jain81b] Jain, R., "Extraction of motion information from peripheral processes," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-3, No. 5, pp. 489-503, 1981.

Motion detection based on difference pictures as an early warning signals during motion perception is discussed. This paper is a more elaborate version of [Jain81a].

[Joha75] Johansson, G., "Visual motion perception," Scientific American, Vol. 232, No. 6, pp. 76-88, June 1975.

The author conducts a number of experiments to analyze the human motion perception. He concludes that human beings tend to perceive objects as possessing constant Euclidean shapes in rigid motion in a three dimensional world.

[Kahn77] Kahn K. and G.A. Gorry, "Mechanizing temporal knowledge," Artificial Intelligence 9 (1977), pp. 87-108.

This paper describes the construction of a "time specialist" that can be used by a higher level problem solver to deal with the temporal aspects of its problem solving. 3 different ways of organizing temporal specifications in the memory are also described

[Kant84] Kant, K. and S. Zucker, "Trajectory planning in time-varying environments, 1:TPP=PPP+VPP," Proceedings of SPIE, Vol. 521, Intelligent Robots and Computer Vision, pp. 220-227, 1984.

A trajectory planning problem (TPP) is decomposed into two subproblems: (1) path planning problem (PPP) to avoid collision with static obstacles, and (2) velocity planning problem (VPP) to avoid collision with moving obstacles. TPP problems have found applications in robotics.

[Kazo84] Kazor, N., "Target tracking based scene analysis," Technical Report No. CAR-TR-88, Center for Automation Research, University of Maryland, Aug. 1984.

A system is developed that aims at building a description model of a stationary scene by tracking known moving targets. This is accomplished by detecting instances of occlusion which provides indication of stationary objects' locations. There are three processing stages: target recognition, segmentation of time-varying images, and scene model generation.

[Kell71] Kelly, M.D., "Edge detection in pictures by computer using planning," in *Machine Intelligence 6*, B. Meltzer and D. Michie, eds., American Elsevier, New York, pp. 397-409, 1971.

The original picture of a man's head is reduced by a factor of 8. Edges detected in the reduced picture are used as a plan for finding the

head's outline in the original picture.

[Klin80] Klinger, A., "Searching images for structure," in [Tani80a], pp. 151-167, 1980.

The article analyzes the inherent structure in an image. Within the context of regular decomposition data structures, it demonstrates how structural symmetry, pattern complexity, and the discovery of inherent structure are related.

[Koss78] Kosslyn, S.M. and Shwartz, S.P., "Visual images as spatial representations in active memory," in [Hans78a], pp. 223-241, 1978.

Motivated by findings in psychology that humans maintain pictorial representations of images in their short-term memories, this paper describes a computer simulation that generates spatial representations of images in short-term memory based on "perceptual" models stored in long-term memory.

[Krug79] Kruger, R.A., C.A. Mistretta, T.L. Houk, S.J. Riederer, S.M.C.G. Shaw, M.M. Goodsitt, A.B. Crummy, W. Zwiebel, J.C. Lancaster, G.G. Rowe and D. Flemming, "Computerized fluoroscopy in real-time for non-invasive visualization of the cardiovascular system preliminary studies," Radiology, Vol. 130, pp. 49-57, 1979.

A computerized fluoroscopic system with dedicated real-time hard-wired algorithms can be used for cardiovascular imaging with or without inject of iodine. Two modes are presented: mask mode and time interval differencing mode.

[Krus80] Kruse, B., "System architecture for image analysis," in [Tani80a], pp. 169-212, 1980.

The design and implementation of a parallel vision system, known as PICAP, is presented. The machine belongs to the SIMD category.

[Krus83] Kruse, B., "Hardware structures for parallel picture processing," in [Faug83], pp. 417-423, 1983.

Data-flow, pipelining, SIMD and MIMD architectures are discussed in the context of picture processing.

[Kush82] Kushner, T., A.Y. Wu and A. Rosenfeld, "Image processing on ZMOB," IEEE Trans. Computers, Vol. C-31, No. 10, pp. 943-951, 1982.

ZMOB described here is an MIMD systems consisting of 256 Z80A microprocessors connected together by a ring-shaped high-speed communication system. Each ZMOB processor receives one of the 256 parts of a image from the host VAX and operates on its pixels, and the results are returned to the host.

[Land81] Landgrebe, D.A., "Analysis technology for land remote sensing," Proc. IEEE, Vol. 69, No. 5, pp. 628-642, 1981.

Current and future analysis algorithms of aerial images are discussed.

[Lato83] Latombe, J.C. and A. Lux, "Basic notions in knowledge representation and control for computer vision," in [Faug83], pp. 323-371, 1983.

Three basic methods in knowledge representation and control for computer vision is presented. They are predicate calculus, production systems, and semantic networks.

[Lawt83] Lawton, D.T., "Processing translational motion sequences," Computer Vision, Graphics & Image Processing, Vol. 22, pp. 116-144, 1983.

A method for analyzing translational motion is proposed. Features of objects are extracted followed by a search that determines the image displacement paths.

[Lees71] Leese, J.A., C.S. Novak and V.R. Taylor, "The determination of cloud pattern motions from geosynchronous satellite image data," Pattern Recognition, Vol. 2, pp. 279-292, 1971.

This paper describes two techniques for computing the cloud motions over the time interval between two digitized pictures. One technique is a direct application of cross-correlation using the FFT. The other uses a simple matching technique.

[Legt82] Legters, G.R. and T.Y. Young, "A mathematical model for computer image tracking," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-4, No. 6, pp. 583-594, 1982.

Translation and rotation operators are first derived to described the motion. A variational estimation algorithm is then used to track the dynamic parameters of the operators by iteratively minimizing variational errors. A predictive Kalman filter is also used to alleviate occlusion problems.

[Less80] Lesser V.R. and L.D. Erman, "Distributed interpretation: a model and experiment," IEEE Trans. Computers, C-29, pp. 1144-1162, Dec. 1980.

A distributed Hearsay II is described with different communication policies discussed. Experimental results with a 3-node system are given.

[Less81] Lesser V.R. and D.D. Corkill, "Functionally accurate, cooperative distributed systems," IEEE Trans. Systems, Man & Cybernetics, SMC-11, pp. 81-96, Jan. 81.

The FA/C approach described in this paper differs from conventional ones in its emphasis on handling distributed-caused uncertainty and errors as an integral part of the network problem-solving process. Nodes cooperate with each other by exchanging partial tentative results with the context of common goals.

[Levi78] Levine, M.D., "A knowledge-based computer vision system," in [Hans78a], pp. 335-352, 1978.

A three-level hierarchical vision system is described. Pictures are segmented at the lowest level and the intermediate level merges regions

based on some knowledge about model features and structures. The highest level then interprets them using a relational model about the world that is stored in a long-term memory. The interpretations are kept and ordered in a short-term memory.

[Levi80] Levine, M.D., "Region analysis using a pyramid data structure," in [Tani80a], pp. 57-100, 1980.

This article demonstrates how a picture can be segmented into regions in an effective manner using a pyramid structure.

[Levi83] Levine, M.D., P.B. Noble and Y.M. Youssef, "A rule-based system for characterizing blood cell motion," in [Huan83], pp. 663-709, 1983.

The rule-based vision system described in this paper is capable of tracking blood cells in spite of their continual structural changes. Incremental shape change detection is accomplished by polygonal approximation and decomposition followed by a rule-based syntactic analysis and a symbolic shape description technique.

[Limb75] Limb, J.O. and J.A. Murphy, "Estimating the velocity of moving images form television signals," Computer Graphics & Image Processing, Vol. 4, pp. 311-327, 1975.

A simple algorithm that estimates the speed of a moving object in a television scene is presented. The algorithm assumes a single object in the scene and pure horizontal translational motion.

[Marr78] Marr, D., "Representing visual information - a computational approach," in [Hans78a], pp. 61-87, 1978.

The author proposes 3 levels of representation for visual information: (1) primal sketch, (2) 2-1/2 D sketch, and (3) 3-D model.

[Marr80] Marr, D. and E. Hildreth, "Theory of edge detection," Proc. R. Soc. London, Vol. B207, p.187-217, 1980.

Detection of intensity changes by zero-crossing at different channels permits deduction of a set of image descriptions called the raw primal sketch.

[Mart78] Martin, W.N. and J.K. Aggarwal, "Survey, dynamic scene analysis," Computer Graphics and Image Processing, Vol. 7, pp. 356-374, 1978.

A review of some 18 papers dealing with motion detection (peripheral processes) and 5 papers with motion analysis (attentive processes) published between 1970 and 1977 is given.

[Mart79] Martin, W.N. and J.K. Aggarwal, "Computer analysis of dynamic scenes containing curvilinear figures," Pattern Recognition, Vol. 11, pp. 169-178, 1979.

The tokens used for matching in the system described in this paper are circular arcs approximated by portions of the object boundaries. Displacements of edge segments grown from matched arcs serve as a measure of motion. Grouping of such segments enable detection of

object motion even in occlusion situations.

[Mart80] Martin W.N. and J.K. Aggarwal, "Occlusion in dynamic scene analysis," in [Simo80], pp. 579-590, 1980.

Two methods of occlusion analysis are given in this paper. One relies on "false vertices" in a domain of polygonal figures. The other uses segments of object's boundary in a domain of curvilinear figures.

[McCo63] McCormick, B.H., "The Illinois pattern recognition computer - Illiac III," IEEE Trans. Computers, Vol. EC-12, No. 6, pp. 791-813, Dec. 1963.

Illiac III is a 32×32 array processors proposed for use in analyzing traces in bubble-chamber photographs. Each processor communicates with 8 neighbors and contains 10 binary registers.

[McDe82] McDermott, D., "A temporal logic for reasoning about processes and plans," Cog. Sci., Vol. 6, pp. 101-157, 1982.

A first-order temporal logic is developed, in which, it is possible to name and prove things about facts, events, plans, world histories. In particular, the logic provides analysis of causality, continuous change in quantities, the persistence of facts (the frame problem), and the relationship between tasks and actions.

[Mins75] Minsky, M., "A framework for representing knowledge," in [Wins75], pp. 211-280, 1975.

The author proposes a set of interlocking symbolic structures, called "frames" that hold information produced from visual analysis and are capable of supplying guesses about things either partly obscured or never looked at.

[Mutc84] Mutch, K.M. and W.B. Thompson, "Hierarchical estimation of spatial properties from motion," in [Rose84a], pp. 343-354, 1984.

A hierarchical token matching is described, the tokens being image feature points. A model of multiresolution motion analysis is then proposed which integrates disparities determination and interpretation of three-dimensional scene properties.

[Nage81] Nagel, H.-H., "Representation of moving rigid objects based on visual observations," IEEE Trans. Computer, Vol. 14, No. 8, pp. 29-39, 1981.

3-D descriptions of a moving rigid object can be derived from a monocular TV frame sequence. A traffic scene is tested in which a polyhedral convex hull approximation is derived from a moving vehicle.

[Nage83] Nagel, H.-H., "Overview on image sequence analysis," in [Huan83], pp. 2-39, 1983.

An overview of current research in the following areas is given: (1) Application of image sequence analysis, (2) Hierarchy of abstraction for motion description, (3) Motion descriptor construction by aggregation within and between images, (4) Determination of displacement vector fields, (5) 3-D point configurations from image sequences, and (6)

Change detection and analysis.

[Neum84] Neumann, B., "Optical flow," Computer Graphics, Vol. 18, No. 1, pp. 17-19, Jan. 1984.

A brief survey of approaches to computing and exploiting optical flow is given.

[Neva78] Nevatia, R., "Characteristics and requirements of computer vision systems," in [Hans78a], pp. 81-87, 1978.

Three broad classes of vision systems of increasing generality are defined with particular emphasis on the most general class.

[ORou80] O'Rourke, J and N.I. Badler, "Model-based image analysis of human motion using constraint propagation," IEEE Trans. Pattern Analysis & Machine Intell., Vol. PAMI-2, No. 6, pp. 522-536, 1980.

A top-down approach of motion analysis is proposed by the author. A model of the human body encoded in Minsky's frame like structures is used for image interpretation and prediction of future positions of the body.

[Pari78] Parikh, J.A. and A. Rosenfeld, "Automatic segmentation and classification of infrared meteorological satellite data," IEEE Trans. Systems, Man & Cybernetics, Vol. SMC-8, pp. 736-743, 1978

The paper describes a cloud-type classification algorithm for infrared satellite pictures. The algorithm first performs gray-level segmentation and then classifies the segments based on textural, tonal, and/or edge features.

[Pete75] Peterman, R., "Computer analysis of planar motion of polygons," Master's Thesis, University of Texas at Austin, Jan. 1975.

Occlusion involving polygonal objects is analyzed.

[Pott75] Potter, J.L., "Scene segmentation by velocity measurements obtained with a cross-shaped template," *4IJCAI*, U.S.S.R., pp. 803-808, 1975.

A cross-shaped template described here is found by determining the distances in four directions from a given pixel to the nearest gray level discontinuity. The template is used for matching in tracking cloud movements.

[Pott83] Potter, J.L., "Image processing on the massively parallel processor," IEEE Computer, Vol. 16, No. 1, pp. 62-67, 1983.

The MPP is an SIMD machine consisting of 128×128 microprocessors. It is developed for use in Landsat image processing.

[Prat84] Pratt, T.W., "PISCES user's manual," University of Virginia, Aug. 1984.

PISCES stands for *Parallel Implementation of Scientific Computing EnvironmentS*. It is a virtual MIMD parallel system. This manual contains two parts: (1) system overview, and (2) language syntax

(fortran 77/unix version).

[Prat85] Pratt, T.W., "Pisces: An environment for parallel scientific computation," IEEE Software, Vol.2, No.4, pp.7-20, July 1985.

An overview of Pisces environment with examples from a sample application program is given.

[Pres79] Preston, K., M.J.B. Duff, S. Levialdi, P.E. Norgren and J.-I. Toriwaki, "Basics of cellular logic with some applications in medical image processing," Proc. IEEE, Vol. 67, No. 5, pp. 826-856, 1979.

Cellular logic refers to an image transformation operation based on neighborhood values. This paper discusses its theory and applications, and surveys several cellular logic machines (e.g. Illiac III, PICAP, cytocomputer, CLIP series, etc).

[Pres81] Preston, K., "Comparison of parallel processing machines: a proposal," in [Duff81], pp. 305-324, 1981.

The author proposes a benchmarking methodology for comparing performances of parallel processors used in image processing. Four machines are tested with a number of benchmark tasks.

[Pres82] Preston, K. and L. Uhr, eds., *Multicomputers for Image Processing: Algorithms and Programs*, Academic Press, New York, 1982.

This book is a collection of papers presented in a series of workshops, addressing three major topics: (1) architectures of multicomputer arrays and networks, (2) higher level languages that encourage formulation of parallel programs, and (3) algorithms for arrays and networks. 34 papers. 470 pages.

[Radi80] Radig, B. and H.-H. Nagel, "Evaluation of image sequences: a look beyond applications," in [Simo80], pp. 525-560, 1980.

This is a very comprehensive review article on motion analysis research from three different points of view: (1) applications, (2) matching techniques, and (3) displacement estimation. It contains 119 references.

[Reed82] Reed, E. and R. Jones, eds., *Reasons for Realism*, Lawrence Erlbaum Associates, Publishers, 1982.

A collection of papers by J.J. Gibson whose main areas of research include human motion perception and ecological optics.

[Reev81] Reeves, A.P., "The anatomy of VLSI binary array processors," in [Duff81], pp. 267-282, 1981.

A VLSI implementation of PE array is proposed, with the following features: limited local memory, fault tolerance, a limited table-look-up capability, and optimal execution speeds for arithmetic operations including multiplication.

[Reev84] Reeves, A.P., "Parallel computer architectures for image processing," Computer Vision, Graphics and Image Processing, Vol. 25, pp. 68-88, 1984.

The author surveys a number of parallel machines for image processing under the following categories: pipeline, SIMD, MIMD and MSIMD (multiple SIMD). He also proposes a simple SIMD/MIMD computational model.

[Reic79] Reichardt, W. and T. Poggio, "Figure-ground discrimination by relative movement in the visual system of the fly, part I: experimental results," Biology and Cybernetics, Vol. 35, pp. 81-100, 1979.

The motion detection and measurement in the visual system of the fly is based on nonlinear multiplication-like interactions between adjacent pairs and groups of photoreceptors. A fly can detect and discriminate a figure that moves relative to a ground of similar texture.

[Reyn82] Reynolds, C.W., "Computer animation with scripts and actors," Computer Graphics, Vol. 16, No. 3, pp. 289-296, Jul. 1982.

The author develops an Actor/Scriptor Animation System which contains a set of independent animation modules, called *actors*, working in parallel. Actors, which can communicate with each other through message passing, are activated by an animated sequence called the *script*.

[Roac79] Roach, J.W. and J.K. Aggarwal, "Computer tracking of objects moving in space," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-1, No. 2, pp. 127-135, 1979.

A method to detect motion of blocks in 3-D space from sequence of 2-D images is developed. Matching is done at three hierarchical levels: motion matching, relative position matching and face matching.

[Roac80] Roach, J.W. and J.K. Aggarwal, "Determining the movement of objects from a sequence of images," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-2, No. 6, pp. 554-556, 1980.

The authors propose a solution that recover 3-D structure and motion from a sequence of 2-D images based on a set of non-linear equations. Two views of six points or three views of four points are needed to provide sufficient number of variables.

[Robb83] Robbins, J.D. and A.N. Netravali, "Recursive motion compensation: a review," in [Huan83], pp. 76-103, 1983.

A number of recursive motion estimation algorithms are surveyed. These algorithms basically start with an initial estimate of the motion parameters and revise these estimates periodically by minimizing the squared value of the displaced frame difference.

[Rose83a] Rosenfeld, A., "Parallel image processing using cellular arrays," IEEE Computers, Vol. 16, No. 1, pp. 14-20, 1983.

Parallelism through the use of two-dimensional array processors is illustrated with a variety of parallel algorithms described. Pyramid and graph structures are also briefly covered in the paper.

[Rose83b] Rosenfeld, A., "Motion: analysis of time-varying imagery," in [Faug83], pp. 173-183, 1983.

The paper discusses two classes of motion estimation methods, region-based and pixel-based. The former includes token matching and picture differencing. The latter includes neighborhood matching and spatial-temporal gradient.

[Rose83c] Rosenfeld, A., "Hierarchical representation: computer representations of digital images and objects," in [Faug83], pp. 313-324, 1983.

The paper reviews some basic methods of representing digital images, with emphasis on hierarchical methods involving pyramids and quadtrees.

[Rose84a] Rosenfeld, A., ed., *Multiresolution Image Processing and Analysis*, Springer-Verlag, 1984.

The papers in this book are the result of a workshop in July, 1982. There are 7 parts: (1) Image pyramid and their uses, (2) architecture and systems, (3) modelling, processing, and segmentation, (4) Features and shape analysis, (5) Region representation and surface interpolation, (6) time-varying analysis, and (7) applications. 22 papers. 385 pages.

[Rose84b] Rosenfeld, A., "Some useful properties of pyramids," in [Rose84a], pp. 2-5, 1984.

This is an introduction to the pyramid data structure, covering various types of pyramids and their usages, such as the divide-and-conquer principle and the concept of action-at-a-distance (permitting local interactions between features that are far apart in the original image).

[Rose84c] Rosenfeld, A., "The prism machine: an alternative to the pyramid," Technical Report No. CAR-TR-70, Center for Automation Research, University of Maryland, Jul. 1984.

A prism machine is defined here as a stack of n cellular arrays, each of size $2^n \times 2^n$ with cell (i,j) on level k connected to cells (i,j), $(i+2^k,j)$ and $(i,j+2^k)$ (modulo 2^n) on level k+1. Such a machine is shown to be capable of performing various operations on a $2^n \times 2^n$ image in O(n) time. These include histograming, DFT, and various types of convolution.

[Sace74] Sacerdoti, E.D., "Planning in a hierarchy of abstraction spaces," Artificial Intelligence, Vol. 5, pp. 115-135, 1974.

The author introduces a hierarchical planner, called ABSTRIPS, which is a modification of STRIPS. ABSTRIPS represents a problem domain in successively finer levels of detail and works on its plan in a hierarchical ordering.

[Sace75] Sacerdoti, E.D., *A Structure for Plans and Behavior*, Ph.D. Dissertation, Stanford University, 1975.

A set of running programs, called the NOAH (Nets of Action Hierarchies) system, embodies a procedural net representation in developing strategies for solving problems and monitoring the execution

of the resulting solutions. 156 pages.

[Same84] Samet, H., "A tutorial on quadtree research," in [Rose84a], pp. 212-223, 1984.

The concept, representations, properties and applications of quadtrees are covered in this paper.

[Schu85] Schunck, B.G., "Image flow: fundamentals and future research," IEEE Conf. Computer Vision and Pattern Recognition, pp. 560-571, Jun. 1985.

Algorithms for 3 types of image flows are discussed: (1) simple continuous continuous translation across the image plane, (2) discontinuous image flows due to occlusion, and (3) complicated image flow involving motion not parallel to the image plane. The last type has not been considered by other researchers before and is examined by the author with future research proposed.

[Self84] Selfridge, P.G. and M.A. Derr, "Some experiments in distributed vision," Proceedings of SPIE, Vol. 521, Intelligent Robots and Computer Vision, pp. 384-391, 1984.

The paper presents three distributed algorithms implemented in a master-slave multiprocessor system for object identification and location in a static scene. (1) Hierarchical strategy: low resolution analysis directs slaves to analyze regions of interest at full resolution; (2) Tailored hierarchical strategy: same as (1) except that analysis is tailored according to discriminability of object types given; and (3) Window strategy: slaves analyze uniformly sized windows.

[Shaw84] Shaw, D.E, "SIMD and MSIMD variants of the NON-VON supercomputer," Proc. COMPCON Spring '84, Feb. 1984.

NON-VON 4, a new member of the NON-VON family, functions as an ensemble of one or more independent SIMD machines communicating through a high-bandwidth interconnection network. The author reviews the essential architectural features of the NON-VON family and highlights the principal differences between the NON-VON 4 and its SIMD predecessors.

[Shne84] Shneier, M., "Multiresolution feature encodings," in [Rose84a], pp. 190-199, 1984.

Edge pyramids and quad trees are described, where each node contains data about an edge. Each parent node obtains data from its child nodes through a process of curve fitting and approximation.

[Sieg81] Siegel, H.J., L.J. Siegel, F.C. Kemmerer, P.T. Mueller, H.E. Smalley and S.D. Smith, "PASM: a partitionable SIMD/MIMD system for image processing and pattern recognition," IEEE Trans. Computers, Vol. C-30, pp. 934, 1981.

The PASM system consists of Q processors in an MIMD organization, each processor having an SIMD organization of Q/N PE's, where N and Q are powers of 2, (possibly 1024 and 16 respectively). The system may be partitioned into a number of different sized SIMD systems by

linking adjacent controllers.

[Simo80] Simon J.C. and R.M. Haralick, eds., *Digital Image Processing*, Proceedings of the NATO Advanced Study Institute, Bonas, France, 1980.

There are four sections in this book: (1) issues of general interest, (2) feature detection and evaluation, (3) scenes and shapes, and (4) applications. 30 papers. 596 pages.

[Skol85] Skolnick, M.M., "Automatic comparison of 2-D electrophoretic gels," IEEE Conf. on Computer Vision and Pattern Recognition, pp. 48-54, 1985.

The paper describes an algorithm for comparing spots on different gels. The algorithm is used in human genetic mutations studies. It is implemented in the system described in [Ster83].

[Skrz84] Skrzypek, J. and D. Shulman, "Preprocessing using multiresolution lateral inhibition," Proceedings of SPIE, Vol. 521, Intelligent Robots and Computer Vision, pp. 91-97, 1984.

A mechanism is derived that permits machine visual response to a wide intensity as in the case of biological systems. This is achieved by automatic shifting of the response curve based on the global and local responses obtained from a multiresolution operator structure. A simulation with two levels of resolution is implemented.

[Smit72] Smith, E.A. and D.R. Phillips, "Automated cloud tracking using precisely aligned digital ATS pictures," IEEE Trans. Computers, Vol. C-21, No. 7, pp. 715-729, 1972.

Cloud motion is measured by tracking clouds over a digital picture sequence by applying two-dimensional cross-correlation analysis. Pictures analyzed are from ATS-I and ATS-III satellites.

[Smit80] Smith R.G. , *A framework for Distributed Problem Solving* UMI Research Press, 1980.

This book describes in detail the "contract net" framework. A more concise treatment of "contract net" can be found in [Smit81]. 173 pages.

[Smit81] Smith R.G. and R. Davis, "Frameworks for cooperation in distributed problem solving," IEEE Trans. Systems, Man & Cybernetics, SMC-11, pp. 61-70, Jan. 1981.

Two forms of cooperation in distributed problem solving are considered: task sharing and result sharing. In the former, nodes assist each other by sharing the computational load in the form of "contract net" negotiation. In the latter, nodes assist each other by sharing partial results.

[Snyd81] Snyder, W.E., "Computer analysis of time-varying images," IEEE Computer, Vol. 14, No. 8, pp. 7-9, 1981.

An overview of computer analysis of time-varying images and its application is given, followed by an introduction to the six articles that appear in the current issue of Computer.

[Stee81] Steeb R., S. Cammarata, F.A. Hayes-Roth, R.W. Thorndyke and R.B. Wesson, "Distributed intelligence for air fleet control," Rand Report R-2728-ARPA, Oct 1981.

This report describes 6 distinct architectures for distributed air traffic control. One the 6 architectures is treated with greater detail to serve as an example of an ATC scenario.

[Stef80] Stefik, M.J., *Planning with Constraints*, Ph.D. Dissertation, Stanford University, 1980.

A "constraint posting" approach to problem solving is introduced in which constraints are dynamically formulated and propagated during hierarchical planning in order to coordinate the solutions of subproblems. A meta-planning scheme is also introduced. These techniques are illustrated in the context of MOLGEN that plans gene cloning experiments in molecular genetics. 242 pages.

[Ster83] Sternberg, S.R., "Biomedical image processing," IEEE Computer, Vol. 16, No. 1, pp. 22-33, 1983.

The pipelined architecture of the cytocomputer is described and its application in human genetic mutation studies is also explained. The algorithm used in the paper may be found in [Skol85] in greater detail.

[Suss75] Sussman, G.J., *A Computer Model of Skill Acquisition*, New York, American Elsevier, 1975.

The author models a system, known as HACKER, that learns and develops plans for manipulating toy blocks.

[Tan85a] Tan, C.L., and W.N. Martin, "Distributed processing for multiresolution dynamic scene analysis," Second Annual Computer Science Symposium - Computer Vision : Motion and Representation, University of South Carolina, Columbia, South Carolina, April 18, 1985.

Preliminary work and future proposal of this dissertation research are presented.

[Tan85b] Tan, C.L. and W.N. Martin, "Distributed processing for multiresolution dynamic scene analysis," 3rd Workshop on Computer Vision: Representation and Control, IEEE Computer Society, Bellaire, Michigan, pp. 141-147, Oct. 1985.

The paper describes our major early work. The workings of the system in tracking with ambiguity and occlusion are discussed and the handling of continuous image arrivals are proposed.

[Tan86a] Tan, C.L. and W.N. Martin, "Hierarchical structures, parallelism and heuristic planning in analyzing time-varying images," Hybrid Image Processing Symposium, Society of Photo-optical Instruments, Orlando, Florida, Mar. 31 - Apr. 4 1986.

Our model is presented in this paper as a hybrid of three recent advances in computer science, namely, hierarchical structures, parallelism and heuristic planning.

[Tan86b] Tan, C.L. and W.N. Martin, "A distributed system for analyzing time varying multi-resolution imagery," Computer Vision, Graphic and Image Processing, special issue on computer vision, to be published.

An expanded version of [Tan85b], with later stages of this reseach also included.

[Tan86c] Tan, C.L. and W.N. Martin, "A distributed system for analyzing time varying multi-resolution imagery," Computer Science Report No. TR-86-01, University of Virginia, Jan. 1986.

[Tan86b] is here reproduced as a technical report.

[Tani80a] Tanimoto, S. and A. Klinger, eds., *Structured Computer Vision*, Academic Press, 1980.

This book is a collection of papers that survey various parallel processing techniques using hierarchical data structures. 9 papers. 234 pages.

[Tani80b] Tanimoto, S., "Image data structures," in [Tani80a], pp. 31-55, 1980.

Data structures essential for computer vision are presented with special emphasis on hierarchical structures: pyramids, cones, trees, and regular decompositions.

[Tani81] Tanimoto, S.L., "Template matching in pyramids," Computer Graphics & Image Processing, Vol. 16, pp. 356-369, 1981.

The pyramid structure is first introduced, followed by a recursive algorithm for hierarchical template matching. The paper further shows how this technique offers savings in computation and a considerable degree of insensitivity to noise.

[Tani82] Tanimoto, S., "Programming techniques for hierarchical parallel image processors," in [Pres82], pp. 421-431, 1982.

The design of a VLSI pyramid machine, which is under construction, is described. Each pyramid layer is a binary array processor with four neighbors per PE.

[Tani84] Tanimoto, S.L., "Graphical operations in a hierarchical parallel computer," Proceedings of SPIE, Vol. 521, Intelligent Robots and Computer Vision, pp. 195-201, 1984.

Several kinds of graphical operations are described that can run efficiently in parallel on pyramid machines. Included are generation of geometric figures such as circles and lines, and stylizations of input images.

[Tate75] Tate, A., "Interacting goals and their use," Proc. 4IJCAI, Russia, pp. 215-218, 1975.

A planner called INTERPLAN is described in this paper. INTERPLAN has provisions for backtracking by reordering subgoals.

[Thom81] Thompson, W.B. and S.T. Barnard, "Lower-level estimation and interpretation of visual motion," IEEE Computer, Vol. 14, No. 8, pp.20-28, 1981.

This paper surveys three approaches to low-level motion analysis, namely, difference techniques, temporal-spatial gradient techniques and matching techniques. Examples of the latter two techniques are described and discussed in greater detail.

[Thom84] Thomas, B.H. and W.N.Martin, "Pyramid structures in dynamic scenes," Proc. ICPR, Montreal, Canada, pp. 1008-1010, 1984.

The construction and application in dynamic scenes of pipelined pyramid structures are illustrated.

[Thom85] Thomas, B.H. and W.N. Martin, "Heterogeneous and homogeneous processes in multiresolution dynamic scene analysis," *Eighteen Annual International Conference on System Sciences*, Honolulu, Hawaii, Jan.2-4, 1985.

Design considerations of a system consisting of parallel processors for dynamic scene analysis are discussed.

[Tsot75] Tsotsos, J.K., "A prototype motion understanding system," Technical Report No.93, Dept. of Computer Science, University of Toronto, Dec. 1975.

A prototype model for semantic understanding of motion is proposed. Semantic networks are used as representation tools. The model consists of 3 parallel processes: low-level process, observer process and frame interpreter. These processes have access to image data and knowledge data bases. They communicate with with each other through communication monitors.

[Tsot79] Tsotsos. J.K., J. Mylopoulos, H.D. Covvey and S.W. Zucker, "ALVEN: a study of motion understanding by computer," Proc. 6IJCAI, Tokyo, Japan, pp. 890-892, Aug. 1979.

This is a summary paper of [Tsot80].

[Tsot80] Tsotsos J.K., J. Mylopoulos, H.D. Covvey and S.W. Zucker, "A framework for visual motion understanding," IEEE Trans. Pattern Analysis & Machine Intelligence, Vol. PAMI-2, No. 6, pp. 563-573, 1980.

A motion understanding system called ALVEN is described. ALVEN analyzes x-ray films of the human left ventricle and interprets its wall motions, noting any abnormalities.

[Tsot84a] Tsotsos, J.K., "Knowledge and the visual process: content, form and use," Pattern Recognition, Vol. 17, No. 1, pp. 13-27, 1984.

This paper first overviews current representational tools and then examines the knowledge abstractions and interactions that are necessary

in visual sensations and perceptions. Finally, representation issues including schemes, concept representation and organization are discussed.

[Tsot84b] Tsotsos, J.K., "The scope of motion research: from image intensity changes to semantic abstractions," Computer Graphics, Vol. 18, No. 1, pp. 7-9, Jan. 1984.

Three aspects of motion research are outlined. They are (1) Motion sensing, (2) Perception, Interpretation and Description of Motion, and (3) Generation of Motion.

[Tsot84c] Tsotsos, J.K, A.D. Jepson and D.J. Fleet, "Motion understanding meets early vision: an introduction," The First Conference on Artificial Intelligence Applications, Denver, CO, pp. 239-244, Dec. 1984.

A low-level vision model is proposed. It is a new center-surround model and is an extension of the difference of Gaussians (DOG) model. A high-level model is also described which is based on the framework used in the ALVEN design [Tsot80].

[Tsot84d] Tsotsos, J.K., "Representational axes and temporal cooperative processes," Report No. RCBV-TR-84-2, Dept. of Computer Science, University of Toronto, Apr. 1984.

A framework for the integration of time into high-level vision is proposed. Details about knowledge representation and organization, attentive search, and hypothesis structure are given. This framework is implemented in ALVEN.

[Tsot85] Tsotsos, J.K., "Knowledge organization and its role in representation and interpretation for time-varying data: the ALVEN system," Comput. Intell., Vol. 1, pp. 16-32, 1985.

The knowledge representation and conrol strategy involving spatial, temporal and causal reasoning in the ALVEN system are discussed in detail.

[Tsuj79] Tsuji, S., M. Osada and M. Yachida, "Three dimensional movement analysis of dynamic line images," Proc. 6IJCAI, Tokyo, pp. 896-901, Aug. 1979.

A flexible template matching method is used where arcs are divided into short segments and correspondences between segments in consecutive frames established. Moving segments are classified and subsequently grouped into meaningful parts.

[Tsuj80] Tsuji, S., M. Osada and M. Yachida, "Tracking and segmentation of moving objects in dynamic line images," IEEE Trans. Pattern Analysis & Machine Intell., Vol. PAMI-2, No. 6, pp. 516-542, 1980.

This paper is almost identical to [Tsuj79].

[Uhr78] Uhr, L., "Recognition cones, and some test results; the imminent arrival of well-structured parallel-serial computers; positions, and positions on positions," in [Hans78a], pp. 363-377, 1978.

The author develops a "recognition cone" system, based on a parallel-serial model similar to the human visual system. The system is embedded in a larger "SEER" system.

[Uhr80] Uhr, L., "Psychological motivation and underlying concepts," in [Tani80a], pp. 1-30, 1980.

The author explains the similarities between human neural processing and parallel/serial computer architectures as the key design philosophy for machine vision system.

[Uhr83] Uhr, L., "Pyramid multi-computer structures, and augmented pyramids," in [Duff83], pp. 95-112, 1983.

The pyramid multi-computer architectures are examined and compared with array, pipelined and other network structures. The possibility of augmenting a pyramid by integrating it with a single host or a network of several computers is also examined.

[Unge58] Unger, S.H., "A computer oriented towards spatial problems," Proc. IRE, Vol. 46, pp. 1744-1750, 1958.

The first paper to suggest a two-dimensional array of processing elements as a natural computer architecture for image processing and recognition.

[Ullm79] Ullman, S., *The Interpretation of Visual Motion*, MIT Press, Cambridge and London, 1979.

The author develops his theory of "structure from motion" that enables interpretation of 3D structure from motion analysis.

[Ullm81] Ullman, S., "Analysis of visual motion by biological and computer systems," IEEE Computer, Vol. 14, No. 8, pp. 57-69, 1981.

Motion detection and measurement schemes in biological and computer systems are surveyed. There are basically two schemes, namely, intensity-based and token-matching. Finally, uses of motion measurements for making interpretation are illustrated.

[Ullm83a] Ullman, S., "Aspects of visual automation," in [Brad83b], pp. 15-32, 1983.

The paper provides a tutorial review of techniques in computer vision, including attributes-based recognition, correlation, occlusion, 3-D representation, etc.

[Ullm83b] Ullman, S. and E.C. Hildreth, "The measurement of visual motion," in [Brad83b], pp. 154-176, 1983.

The authors give a mathematical treatment on motion measurements under various kinds of constraints. Some biological implications are also discussed.

[Ullm83c] Ullman, S., "Recent computational studies in the interpretation of structures from motion," in [Beck83], pp. 459-480, 1983.

The author reviews and compares results obtained in the computational study of the interpretation of structure from motion. Comparisons are also made between perspective versus orthographic, velocity-based versus position-based, and discrete versus continuous interpretation schemes.

[Vere83] Vere S.A. , "Planning in time: windows and durations for activities and goals," IEEE PAMI-5, No. 3, May 1983. pp. 246-267.

A general planner is described which generates parallel plans to achieve goals with imposed time constraints. Both durations and start time windows may be specified as goal conditions. A start time window for each activity is updated dynamically during plan generation to maintain consistency with the windows and durations of adjacent activities and goals. The final plan is a schedule of start times for various activities.

[Walt78] Waltz, D.L., "A parallel model for low-level vision," in [Hans78a], pp. 175-186, 1978.

A parallel model is presented that involves finding local features (e.g. line or edge segments) and propagating such information whereby important features may be grouped into lines, edges, regions, etc.

[Walt75] Waltz, D., "Understanding line drawings of scenes with shadows," in [Wins75], pp. 19-92, 1975.

The paper describes a program that analyzes line drawing by assigning properties to lines and junctions. The program begins by assigning all possible junction and edge labels and iteratively remove illegal labels based on current contexts until a coherent and unique labelling is reached.

[Ward81] Ward, M.O. and Y.T. Chien, "Occlusion analysis in time-varying imagery," IEEE Conf. Pattern Recognition & Image Processing, Dallas, Texas, pp. 504-507, 1981.

The approach presented in this paper attempts to interpret occlusions using a variety of heuristics based on current and past trends in motion. The occlusion analysis proceeds as follows: (1) detection of occlusions, (2) estimation of type and duration of occlusion, (3) monitoring to verify consistency of estimations, and (4) overall classification of occlusion.

[Warn83] Warnecke, G., "Aspects of dynamic scene analysis in meteorology," in [Huan83], pp. 594-600, 1983.

The past, present and future developments are the aspects discussed in this papers.

[Wass84] Wasserman, K, "Understanding hierarchically structured objects," report No. CUCS-124-84, Columbia University, May, 1984.

The paper presents a formalism for describing hierarchies and then uses this formalism to explore the issues of hierarchy generalization and

multi-source inheritance.

[Webb81] Webb, J.A. and J.K. Aggarwal, "Visually interpreting the motion of objects in space," IEEE Computer, Vol. 14, No. 8, pp. 40-46, 1981.

By assuming fixed axis of rotation over short periods of time and parallel projection, a method is derived for determining the structure and motion of any group of rigidly connected points.

[Wins75] Winston, P., ed., *The Psychology of Computer Vision*, McGraw-Hill, New York, 1975.

The chapters in this book are slightly abridged Ph.D. theses or other similar major works in machine vision research. Topics include line drawing understanding, intensity arrays analysis, shading information, learning, and frames.

[Wong78] Wong, R.Y. and E.L. Hall, "Sequential hierarchical scene matching", IEEE Trans. Computers, Vol. C-27, No. 4, pp. 359-366, 1978.

A hierarchical data structure is used to speed up cross correlation matching. An average reduction in computation by a factor of about 1900 is reported.

[Yach80] Yachida, M., M. Ikeda and S. Tsuji, "A plan-guided analysis of cineangiograms for measurement of dynamic behavior of heart wall," IEEE Trans. Pattern Analysis & Machine Intell., Vol. PAMI-2, No. 6, pp. 537-542, 1980.

Poor picture quality in cineangiograms of a beating heart motivates the design of a vision system described in this paper. Heuristic planning is used here in providing an efficient way for local edge detection and global boundary following.

[Yaki78] Yakimovsky, Y. and R. Cunningham, "A system for extracting three dimensional measurements for a stereo pair of TV cameras," Computer Graphics & Image Processing, Vol. 7, pp. 195-210, Apr. 1978.

A correlation method is used for matching stereo image pairs. Two types of masks, namely, concentric diamonds and four-line segment, are used.

[Yen81] Yen, D.W.L. and A.V. Kulkami, "The ESL systolic processor for signal and image processing," Proc. Workshop Computer Architecture for PAIDM, pp. 265-272, 1981.

The ESL/systolic processor described here is based on the systolic arrays and is developed for signal/image processing operations like multidimensional convolution and resampling.