

# Appendix A

## Original Contributions

This dissertation integrates and builds on previous research published in the following proceedings and journals:

Bollen (1994)  
Bollen (1995)  
Bollen and Heylighen (1996)  
Heylighen and Bollen (1996)  
Bollen and Heylighen (1997)  
Bollen and Heylighen (1998)  
Bollen et al. (1998)  
Bollen, Vandesompele, and Rocha (1999)  
Bollen (1999)  
Bollen (2000)  
Bollen and Rocha (2000).

This chapter will briefly list the original contributions made specifically in this dissertation.

1. Hypertext and WWW
  - (a) Proposal to study human hypertext design and navigation as two processes relying on a body of shared knowledge on concept relations.
  - (b) Relation between human hypertext navigation and Human Problem Solving.
2. Mental Models for Hypertext

- (a) Analysis of hypertext design as application of Designer's Mental Model of associative relations between documents.
- (b) Representation of Designer's Mental Model by weighted, directed graph.
- (c) Operationalization of Designer's Mental Model by structural proximities derived from hyperlink patterns in hypertext.
- (d) Analysis of human hypertext navigation in terms of application of User's Mental Models of associative relations between documents.
- (e) Representation of User's Mental Models by weighted directed graphs.
- (f) Analysis of user group preferences by Collective Mental Models.
- (g) Representation of Collective Mental Models by weighted, directed graph.

### 3. Hill-Climbing Model of Human Hypertext Navigation

- (a) Proposal to analyse human hypertext navigation in terms of interaction between hyperlink structure and User's Mental Model.
- (b) Proposal to model hypertext navigation as Hill-Climb search in hyperlink structure based on User's Mental Model.
- (c) Algorithmic formalization of Hill-Climb Model of human hypertext navigation based on matrix representation of User's Mental Model and hypertext network structure.
- (d) Proposal to model transition of user strategies from recreational to goal-directed by selection and target relaxation, and the use of hyperlink selection probability distributions.

### 4. Experimental Methodology

- (a) Comparison of HCM model path predictions to user navigation paths reconstructed from a web site's log files.
- (b) Generation of CMM representation from user request sequences in web log.
- (c) HCM simulation software to predict user navigation paths.
- (d) Demonstration of presence of hill-climb strategy in hypertext navigation by analysis of PGAS weight values of navigation path intermediate positions..

- (e) Demonstration of relation between navigation path's start and target association weight, and navigation efficiency.

#### 5. Automated Generation of Hyperlinks

- (a) Analysis of adaptive information systems in terms of Designer and User Mental Models
- (b) Proposal to generate hyperlink structure from representation of users' Collective Mental Model for hyperlink design rather than Designer Mental Model.
- (c) A system for the automated generation of hyperlinks from user hyperlink traversal patterns.
- (d) Application of a set of learning rules for hyperlink weights that dynamically change hypertext network during user interaction.
- (e) Reduction of hypertext systems to word networks for purposes of quantitative study.
- (f) Evaluation of adaptive hypertext systems by a measure of reliability and validity of network development.
- (g) Use of simulation of user hyperlink selection behavior to assess re-test reliability and validity of adaptive hypertext system.
- (h) Assessment of concept relation validity in adaptive hypertext by comparison to word association norm data.

#### 6. Implementation of Spreading Activation Recommendation system operating on CMM generated from user request sequences.





## Appendix B

# PCP Labels and Titles

ABSTRACT (Abstraction), ACT (Principia Cybernetica Meetings), ACTION (Action), ADAPNET (Adaptive hypertext network), ADAPSYS (Adaptive syser), ADHYPEXP (The Adaptive Hypertext Experiment), AGENT (Agent), ALEVOMOD (Artificial Life Evolutionary Models), ALPINDEX (Alphabetical Index), ANALSYST (Analytic vs. Systemic Approaches), ANNOHELP (Guidelines for making annotations), APPEVMOD (Applied Evolutionary Modeling), ARIST (Aristocratic rule), ASYMILL (Asymmetric Transitions: an illustration), ASYMTRANS (The Principle of Asymmetric Transitions), ATHEISM (Atheism), ATTRACTO (Attractors), AUTHORIT (Authority), AUTOCAT (The Principle of Autocatalytic Growth), BARTER (Barter ), BEAUTIF (The feeling of beautiful ), BELGCUL (Belgium: Overview), BELGCUL2 (Belgium: society, character and culture), BESWEB (Principia Cybernetica Web and the "Best of the Web" awards), BIOEVOL (Biological Evolution), BIOGRAFJB (Biographical Sketch - J. Bollen), BIOIMM (Biological immortality), BIOLEXAM (Biological examples of MSTs), BLINCTRL (Blind control), BLINDVAR (The Principle of Blind Variation), BOARD (Editorial Board), BOOLNETW (Kauffman's NK Boolean networks), BRUSSEL (Things to see in Brussels), BVSR (Blind Variation and Selective Retention), CAMPBEL (In Memoriam Donald T. Campbell), CAPITAL (Capitalism ), CAS (Complex Adaptive Systems), CAUSE (Causality), CHAOS (Deterministic Chaos), CHINNEG (Change and Information Overload: negative effects), CLOSURE (Closures), CLUSTERW (Cluster Analysis of Word Associations), COGNAILI (Links on Cognitive Science and AI), COGNEVOL (Cognitive Evolution (stages)), COHERENC (Coherence), COLBRAIN (Collective brain of humanity ), COLGRAN (collaborative granularity ), COLL (Collaborators Needed), COLLFILT (Collaborative Filtering), COLLUTIL (Collective Utility), COMMAND (Command), COMMUN (Communication ), COMPGROW (The Growth of Complexity), COMPLEXI (What is complexity?), COMPNATS (Self-organization and complexity in the natural sciences), COMPTABL (Correspondence between Organism and Society), COMSELLI (Links on Complexity, Self-organization and Artificial Life), COMWEBLI (Links on Computer Interfaces and the Web), CONBUILD (Consensus Building), CONCEPT (Concept), CONFLICT (Conflict ), CONFORM (Conformity)

CONSTRUC (Epistemological Constructivism), CONTEXT (Context of Principia Cybernetica), CONTHIER (Control hierarchy ), CONTIN (Continuous vs. discrete), CONTR (Contributing to the Principia Cybernetica Project), CONTROL (Control), CONTROSC (Control in Terms of Statements and Commands), COOPEVOL (Evolution of Cooperation), COOPGEVO (Genetic Scenarios for Evolving Cooperation), COOPMEVO (Memetic Scenarios for Evolving Cooperation), COPYR (Principia Cybernetica Copyright Statement), COSMROL (Cosmic role of humankind ), CREATIMM (Creative immortality), CRELANG (Creation of language ), CRITIC (Criticisms of Principia Cybernetica), CSBOOKS (Basic Books on Cybernetics and Systems Science), CSCW (Computer-Supported Cooperative Work), CSMAIL (Mailing Lists and Newsgroups on Cybernetics and Systems), CSPAPER (Basic Papers on Cybernetics and Systems Science), CSTHINK (Cybernetics and Systems Thinkers), CULTURE (Culture ), CYBERN (Cybernetics), CYBFOUND (Existing Cybernetic Foundations), CYBIMM (Cybernetic Immortality), CYBINT (Cybernetics and the Integration of Knowledge), CYBSACAD (Cybernetics and Systems Science in Academics), CYBSCOMP (Cybernetics and Systems Science Compendia), CYBSHIST (History of Cybernetics and Systems Science), CYBSNAT (The Nature of Cybernetic Systems), CYBSPACE (Cyberspace), CYBSPASY (Symposium: Theories and Metaphors of Cyberspace), CYBSPRIN (Principles of Systems and Cybernetics), CYBSREL (Relation to other disciplines), CYBSWHAT (What are Cybernetics and Systems Science?), CYBSYSLI (Links on Cybernetics and Systems), CYBSYSTH (Cybernetics and Systems Theory), CYBTECH (Cybernetic Technology), CYBTHPRA (Cybernetic Theory and Cybernetic Practice), DEFAULT (Welcome to Principia Cybernetica Web), DEFFORM (Formality), DEMOCR (Democracy ), DIREVOL (The Direction of Evolution), DISTFOUND (Distinction foundations: evolution of meaning), DISTINCT (Distinction), DISTINCTV (Distinctiveness), DOMAIN (Domain), DOUBT (Doubt), DOWNCAUS (Downward Causation), EINMAGSY (Symposium : The Evolution of Complexity), EMERGE (Emergence), EMPIR (Empire ), ENTRTHER (Entropy and the Laws of Thermodynamics), EPISTEM (Epistemology), EPISTEMI (Epistemology, introduction), ESTEVR (Estimation of the evolution rate), ETERQUES (Eternal Philosophical Questions), ETHICS (Ethics), ETHICSI (Ethics, introduction), EUKARYOT (Eukaryotes: the origin of complex cells), EVENT (Event), EVOCOPUB (Classic Publications on Complex, Evolving Systems), EVOLAGE (The Evolutionary Causes of Aging and Death), EVOLEPIST (Evolutionary Epistemology), EVOLETHICS (Evolutionary origin of ethical systems), EVOLSYS (Evolutionary Systems), EVOLUT (Evolutionary Theory), EVOLVAL (Evolutionary Values), EVOMEMLI (Links on Evolutionary Theory and Memetics), EXAMCTRL (Examples and Counterexamples of Control Systems (empty)), EXEC (Executive power ), EXMID (The law of the excluded middle), EXPERIM (Experiment ), FEEDBACK (Feedback), FITNESS (Fitness), FITTRANS (Definition of Fitness in terms of transition probabilities), FORMALIZ (Formalization), FOUNDCONC (Foundational Concepts), FOUNDMAT (Foundation of Mathematics), FPUBINT (First public introduction of the Principia Cybernetica Project), FREECONS (Freedom and Constraint in a Metasystem Transition), FREEDOM (Determinism vs. Freedom), FTPTREE (Tree of FTP directories)

FUN (The feeling of funny ), FUTDEVL (Links on Future Development), FUTEVOL (The Future of Humanity), FUZZY (Fuzzy logic and sets ), GABORA (About Liane Gabora), GATHVAR (Gathering a variety of contributions), GBRAINREF (References on the Global Brain / Superorganism), GBRAISUB (Subscription to the Global Brain mailing list), GENETALG (Genetic Algorithms), GENMODEV (General Models of Evolution), GOAL (Goal ), GOD (God), GODEXIST (Arguments for and against the Existence of God), GROWTH (Growth ), HAPPINES (Happiness), HARMOSCL (The Harmonic Oscillator as a Control System), HELPTAS (Tasks with which you can help), HEYBIO (F. Heylighen: Biographical Sketch), HEYL (Home page of Francis Heylighen), HIERARCH (Hierarchy ), HIGHVAL (Highest values ), HISTEVOL (The History of Evolution), HISTOREC (Historic record), HISTORY (History of the Principia Cybernetica Project), HOMEOSTA (Homeostasis), HOMOMORP (Homomorphism), HOWWEB (How to use Principia Cybernetica Web), HUMFREE (Human Freedom ), HUMLANG (Human language), HUMRIGHT (Human Rights), HYPERC (Hypercycles), IAC (IAC - International Association for Cybernetics), IDENINDI (The Identity of the Indistinguishables), IMAGIN (Imagination ), IMMORT (Will for immortality), IND-COLL (Individualism vs. collectivism ), INDENCLI (Links on Indexes and Encyclopedias), INDEX (Search), INDUTIL (Utility), INFINITY (Infinity), INFOJB (Johan Bollen), INFORM (Information ), INSECSOC (Insect Societies), INSTMEAN (Instrumental meaning), INSTVAL (Institutionalization of values ), INTDIF (Integration and differentiation), INTERFAC (Direct Interfaces into the Global Brain), INTFREE (Integration and freedom), INTRO (Introduction to Principia Cybernetica), INTUIT (Intuition), INVARIAN (Invariance), IRRIT (Irritability ), ISOMCTRL (Other Definitions of Control), JMDEWAE (About Jean-Marc Dewaele), JOSLYN (About Cliff Joslyn), JOURNALS (Cybernetics and Systems Journals), JUDIT (Judiciary ), KASCHO (From Kant to Schopenhauer), KNOW (Knowledge), KNOWSELC (Knowledge Selection Criteria), KNOWSTRUC (Bootstrapping Methods for Knowledge Structuring), LANG (Language), LEARNING (Learning ), LEARNWEB (Learning Webs), LEGIS (Legislative power ), LINGACT (Four types of linguistic activities), LINKTYPE (Links and Link Types), LISTSV (PCP-discuss usage instructions), MACHINE (Machine ), MACRBOOK ("The Macroscope", a book on the systems approach), MAIL (Principia Cybernetica Mailing Lists), MANIFESTO (The Cybernetic Manifesto), MARKET (Market ), MASTHEAD (Principia Cybernetica Masthead), MATHME (Mathematical Modeling of Evolution), MATHMPG (Mathematical Methods of Population Genetics), MEAN1ST (Meaning Goes First ), MEANING (Meaning), MEANLIFE (What is the meaning of life?), MEANMET (The meaning of metaphysics), MEASFOR (Measuring formality through word frequencies), MEMEEVOL (Memetic Evolution), MEMENET (Memes on the Net), MEMES (Memetics), MEMETSY (Symposium on Memetics), MEMGEN (Competition between Memes and Genes), MEMIN (Memes: Introduction)

MEMLEX (Memetic Lexicon), MEMSELC (Memetic Selection Criteria), MEMSTRUC (Structure of memes), MESSAGE (Message), METACOGN (Meta-Cognitive Modelling), METALARE (Metalanguage), METAPHI (Metaphysics, introduction), METAPHYS (Metaphysics), METHODOL (Methodology for the Development of MSTT), METIMM (Metaphysical immortality), MINIMAX (Principles of Reasoning with Uncertainty), MODEL (Model), MONEY (Money ), MST (The Metasystem Transition), MSTBIOL (Metasystem Transitions in Biology), MSTQUANT (MST as the quantum of evolution ), MSTT (Metasystem Transition Theory), MSTTYPES (Types of Metasystem Transitions), MULTAXIO (Multiple axiomatization sets, a metaphor for metafoundationalism), MULTBEG (Multiple Beginnings, Meta-Foundationalism), MULTICEL (Multicellular organisms), NATSTAT (Nation state ), NEURLOG (Neuronal vs. logical concepts), NEUTEG (Neutral evolution game), NODEORG (Node Organization), NODSTAT (Node usage statistics), NUMBER (Number), NUTSHELL (Overview of Principia Cybernetica), OBJECT (Object), OBJECTIV (Objectivity), OBJFIC (Objectification), OBSERV (Observation), OCCAMRAZ (Occam's Razor), OLIGAR (Oligarchy ), ONTOLI (Ontology, introduction), ORDER (Order ), ORG (Project Organization), ORIGIN (Models of molecular-genetic systems origin), ORILIFE (The Origins of Life), PANTHEISM (Pantheism), PARSING (Parsing), PCP-MANAG (Management of Principia Cybernetica), PCPNDIGE (PCP-news digest ), PCPNEED (The Need for Principia Cybernetica), PCPNEWS (Principia Cybernetica News), PCPNSUBS (Subscription to PCP-news), PCPUNKNO (Principia Cybernetica as a Universal Knowledge System for Cybernetics and Systems Science), PENULTIM (Branching Growth of the Penultimate Level), PEOPLE (List of contributors), PETERPR (The generalized "Peter Principle"), PHDPCP (Doing PhD or PostDoc Research with Principia Cybernetica), PHILOSI (Philosophy, Introduction), PHILOSLI (Links on Philosophy), PHYSCONS (Physical Constructivism), PLANNING (Planning ), PLAUSIB (Plausibility ), PLAY (Play ), POLITSYS (Political system ), POSBOOK ("The Phenomenon of Science", a book on MSTT), POWRCTRL (Powers' Definition of Control), PREBEVOL (Physical Evolution ), PREDICAT (Predicate), PREDICT (Prediction), PRIM (Primitive culture ), PRIMPROD (Primitive production system ), PRINCAUS (The Principle of Causality), PRISDIL (The Prisoners' Dilemma), PRMAT (Principia Cybernetica and Principia Mathematica), PRNCSUB (Subscription to PCP-discuss), PROBAB (Probability), PROBSOLV (Problem-solving), PROC (Procedure ), PROCESS (Process), PROCMETA (Process Metaphysics), PRODSYS (Production system ), PROGREP (Progress Report: 5 years of PCP), PROGRESS (Societal Progress), PROOF (Proof), PROPCTRL (Properties of a Control System), QUASIS (Quasispecies), REACT (Reactions, discussions, comments), REC93 (Changes-Additions 1993-94), REC94 (Changes-Additions 1994-95), REC95 (Changes-Additions 1995-96), REC96 (Changes-Additions 1996-97), REC97 (Changes-Additions 1997-98), RECENT (Recent Changes/Additions), RECSYSO (The Principle of Recursive Systems Construction), REDKO (About Vladimir Red'ko), REDQUEEN (The Red Queen Principle), REF-CORR (Reflection-correspondence theory), REFLEX (Reflex ), REFSPCP (Reviews of Principia Cybernetica Web by others), REFUT (Refutation )

REGUL (Regulation ), RELATED (Sites Related to Principia Cybernetica), RELIGION (Religion ), REQCONS (Law of Requisite Constraint), REQHIER (Law of Requisite Hierarchy), REQKNOW (The Law of Requisite Knowledge), REQVAR (The Law of Requisite Variety), REVWIR (Principia Cybernetica in "Wired" magazine), SAMPNEWS (Sample Issue of 2-monthly PCP-news), SCICONC (Basic Concepts of Science), SCIEVOL (Science in evolution ), SCIVAL (Science and human values), SCIVIEW (Scientific worldview ), SCOPEMST (The scope of MST ), SEARCHERR (Common Search Errors), SELECT (Selection), SELFKNOW (Self-knowledge ), SELFORG (Self-organization), SELRET (The Principle of Selective Retention), SELVAR (The Principle of Selective Variety), SEMAN (On Semantic Analysis and Consensus Building), SEMANAL (Semantic Analysis), SEMANT (Semantics), SEMCONT (Semantic Control), SEMIOTER (Semiotic Terms), SEMNET (Hypertext web as a semantic network), SENTENCE (Sentence), SEPPOWER (Separation of powers ), SEX (Sexuality as a Metasystem Transition), SINGULAR (The Socio-technological Singularity), SLAVERY (Slavery ), SOCEVOL (Social Evolution), SOCIALISM (Socialism ), SOCIETIES (Cybernetics and Systems Societies), SOCIETY (Human society), SOCINT (Social Integration ), SOCIOBIO (Sociobiology ), SPACE (Space), SPECCTRL (Special Cases of Control), SPINGL (Spin-glass model of evolution), SPIRSYS (Spiritual system ), SPREADACT (Finding words through spreading activation), STABCOOP (Evolutionary stability of cooperation), STATE (State of the world), STATEM (Statement), STATINF (Statement of infiniteness), SUBJ (Subject of knowledge: "I"), SUBMNODE (Submitting Nodes for Inclusion in Principia Cybernetica Web), SUBOPTIM (The problem of suboptimization), SUBSCR (PRNCYB-L Subscribers), SUPBEING (Human super-being ), SUPBRAIN (From World-Wide Web to Super-Brain), SUPORGLI (The Social Superorganism and its Global Brain), SURVIV (Survival), SYMBIMST (Symbiosis as a Metasystem Transition), SYMBOL (Symbol), SYNTAX (Syntax), SYSAPPR (Basic Concepts of the Systems Approach), SYSCONC (Systems Concepts), SYSERS (Sysers), SYSTHEOR (What is Systems Theory?), TECACCEL (Technological acceleration), THEORIES (Theories versus facts), THEISIS (About "Representation and Change"), THINKING (Human thinking), TIME (Time), TOC (Table of Contents), TOOLMAKE (Making tools ), TRIALERR (The trial-and-error method), TRIBE (Primitive tribe ), TRUTH (Truth), TURCBIO (Biographical Notes on Valentin Turchin), TURCHIN (About Valentin Turchin), ULTRAMST (Ultra-Metasystems), UMPLEBY (About Stuart Umpleby), UNSEMLAN (Universal Semantic Language), USANNO (User Annotations), VARIETY (Variety), VERIFIC (Verification), VICARSEL (Vicarious Selectors), VISIFUT (Popular Visions of the Future), VUBULB (The Free University of Brussels), WEBCONAN (Web Connectivity Analysis), WEBORG (Web Organization), WEBRESEA (PCP Research on Intelligent Webs), WEBSTRUCT (Structure of Principia Cybernetica Web), WFISSUE (Special Issue on "The Quantum of Evolution"), WORLVIEW (What is a world view?), ZESUGAM (Zero sum games)