SG1I

* *

SEQUENCE NR: CXA85017099   USE ████████   ID: 00571-90NOV20 14.11.14 A01

TITLE: SOVIETS COMBINE NEUROSCIENCE AND OPTICAL PROCESSING
            TECHNIQUES TO DEVELOP AN OPTICAL BRAIN *U*
DOC REF: BIWEEKLY SCIENTIFIC AND INTELLIGENCE SUMMARY (BSISY), 85,
            07-1 .
DOC NR: AST-060P-328-85 (AST2660P32885)
DOC DATE: 850510
FICHE NR: DST857301303
INF CTY: UUSR (UR)
CLASSIF: CONFIDENTIAL
DWNGRADE: CLASSIFIED BY: MULTIPLE SOURCES; DECLASSIFY ON:
            ORIGINATING AGENCY'S DETERMINATION REQUIRED
RELEASE: ORCON (OC)
DISTRIB: RELEASE LIMITED TO AFMIC, DIA/DT, FSTC, FTD, MSIC, NISC
            (ST)

TEXT: ENTIRE.   THIS INPUT UNIT IS MARKED ACCORDING TO THE OVERALL
      RELEASABILITY RESTRICTION OF THE SOURCE DOCUMENT. TEXT CONTAINS NO
      RELEASABILITY MARKINGS.

      U WITH ADVANCED ELECTROOPTICS TECHNOLOGY, SOVIET ENGINEERS HAVE
      DEVELOPED A DEVICE THAT MIMICS THE HUMAN BRAIN IN THE WAY THAT THE
      BRAIN PROCESSES INFORMATION. LIKE THE REAL THING, THE SOVIET ANALOG
      IS A MULTILEVEL NETWORK OF NERVE CELLS.   THE NATURAL BRAIN, A
      PARALLEL PROCESSOR, CONSISTS OF ABOUT 10^{11} NEURONS OR NERVE
      CELLS, BUT THE GREATER VOLUME IS MADE UP OF ABOUT 10^{14}
      INTERCONNECTIONS AMONG THESE NEURONS.   THE SOVIET ANALOG   IS
      STRUCTURED SIMPLISTICALLY THE SAME WAY BUT USES A THRESHOLD FILTER,
      PHOTOCELL, LASER, AND HOLOGRAM OPERATING IN SERIES AS THE BASIC
      ELEMENT. INTERCONNECTIONS ARE MADE OPTICALLY.

      U THE SOVIET NEURON WORKS IN THIS WAY: WHEN AN INPUT SIGNAL (S) IN
      THE FORM OF LIGHT IRRADIATES THE PHOTOCELL, ITS OUTPUT DRIVES THE
      LASER, WHICH PRODUCES AN OUTPUT THAT IS SPLIT AND MODULATED BY THE
      HOLOGRAM.   AFTER BEING SPLIT, THE LASER ACTIVATES THE PHOTOCELLS AT
      THE NEXT LEVEL. INFORMATION STORED ON THE HOLOGRAMS CONSTITUTES THE
      PROGRAM AND DETERMINES THE INTERCONNECTIONS FOR THE OPTICAL BRAIN.
      THE THRESHOLD FILTER SETS THE MINIMUM LIGHT LEVEL REQUIRED TO
      ACTIVATE THE PHOTOCELL.

      U IN THE REAL BRAIN, THESE INTERCONNECTIONS CAN NUMBER IN THE TENS
      OF THOUSANDS PER NEURONS. STATE-OF-THE-ART MICROELECTRONICS COULD
      NOT BE USED TO SIMULATE THIS STRUCTURE AND STAY WITHIN A REASONABLE
      SIZE.   IN ADDITION TO BEING LIMITED BY PACKING DENSITY OF THE
      CONNECTIONS BETWEEN NEURONS, MICROELECTRONIC CIRCUITS SUFFER FROM
      THE POTENTIAL FOR INFORMATION LEAKAGE FROM CROSS TALK (UNDESIRED
      TRANSFER OF SIGNALS). INTERCONNECTIONS BY OPTICAL RADIATION ARE NOT
      BOUND BY EITHER RESTRICTION.

* *

* *

SEQUENCE NR: CXA85027099   USER-███████   ID: 00571-90NOV20/14.11.14/A01

SG1I

U THE SOVIETS REPORT THAT THEY CAN CONSTRUCT AN OPTONEURON BRAIN WITH THE SAME NUMBER OF NEURONS AND INTERCONNECTIONS AS THE NATURAL BRAIN, USING A MODULAR DESIGN. EACH MODULE WOULD BE THE EQUIVALENT OF A LAYER OF 10EXP3 NEURONS, 10EXP6 INTERCONNECTIONS AND BE PACKED IN A 1 CM CUBE. AS WITH THE NATURAL BRAIN, INFORMATION FROM LAYER TO LAYER IN THE MODEL UNDERGOES HIGHER AND HIGHER DEGREES OF PROCESSING. WITH THREE LAYERS OF NEURONS, THE SOVIET MODEL WOULD BE ABOUT 50 CU M, MANY TIMES LARGER THAN THE NATURAL BRAIN BUT A MANAGEABLE SIZE AS A COMPUTER.

U CONSIDERING SPEED OF PROCESSING, THE OPTONEURON BRAIN, AT 10EXP4 TO 10EXP5 TIMES THE SPEED OF THE NATURAL BRAIN, WOULD BE MUCH FASTER THAN THE STATE-OF-THE-ART ELECTRONIC COMPUTER THAT HANDLES 10EXP7 TO 10EXP9 OPERATIONS PER SECOND. WHILE THE NERVE CELL IS MUCH SLOWER THAN ELECTRONIC DEVICES, THE NATURAL BRAIN, WITH PARALLEL PROCESSING, IS FASTER (IN THE SOLUTION OF NONFORMAL PROBLEMS) THAN THE ELECTRONIC COMPUTER. THE OPTONEURON BRAIN, A PARALLEL PROCESSOR WITH ELEMENTS THAT OPERATE AT ELECTRONIC SPEED, IS STILL FASTER (WITH A SYSTEM SPEED OF 10EXP20 OPERATIONS PER SECOND).

U NOTWITHSTANDING THE SOVIET ACHIEVEMENT IN DEVELOPING THE OPTICAL BRAIN, THE GREATER TASK IS TO DETERMINE THE STRUCTURE OF THE INTERCONNECTIONS. TWO COMPLEMENTARY RESEARCH DIRECTIONS ARE BEING FOLLOWED TO DEVELOP THE ALGORITHMS FOR PROCESSING INFORMATION.

U THE FIRST OF THESE IS THE STUDY OF THE PRINCIPLES AND METHODS OF PROCESSING INFORMATION GLEANED FROM NEUROPHYSIOLOGY RESEARCH. THE WORK OF U.S. SCIENTISTS D. H. HUBEL AND T. N. WIESEL ON THE PRINCIPLES OF PROCESSING IN THE BRAIN OF VISUAL INFORMATION IS A REPRESENTATIVE APPROACH FOLLOWED CLOSELY BY THE SOVIETS. SOVIET ACTIVITY IN THIS AREA IS BRISK.

U THE SECOND WAY IS THE ANALYTIC INFERENCE OF ALGORITHMS WHICH MODEL INDIVIDUAL FUNCTIONS OF THE BRAIN. THE OPTICAL BRAIN BUILT AND DESCRIBED BY THE SOVIETS USES AN ALGORITHM DEVELOPED TO RESEMBLE THE INTELLECTUAL OPERATIONS PERFORMED BY HUMANS IN LOOKING FOR INFORMATION. THE DEVICE DESCRIBED BY THE SOVIETS IS A RELATIVELY SIMPLE SYSTEM THAT USES PATTERN RECOGNITION IN FINDING DOCUMENTS. IN 1980 AND 1981, THE SOVIETS PUBLISHED DETAILS ABOUT THE TECHNIQUE OF A PURELY OPTICAL RETRIEVAL MECHANISM BASED ON HOLOGRAPHY.

U COMMENT: THE SOVIET BRAIN IS A MUCH SIMPLIFIED MODEL OF THE REAL THING. FOR EXAMPLE, THE MODEL, UNLIKE THE REAL BRAIN, IS NEITHER ADAPTIVE NOR CAPABLE OF SELF LEARNING. THE PROGRAM OF THE MODEL IS FIXED BY THE HOLOGRAMS RECORDED ON LIGHT SENSITIVE FILM.

U COMMENT: THE TECHNOLOGY FOR THE FILM DEVELOPED FROM BACTERIORHODOPSIN DESCRIBED IN THE 23 NOVEMBER 1984 ISSUE OF THIS PUBLICATION (AST-2660P-316-84) COULD CHANGE THIS LIMITATION.

* *

SEQUENCE NR: CXA85027099   USER ▮▮▮▮▮   ID: 00571-90NOV20/14.11.14/A01

SG1I

HOLOGRAMS RECORDED ON THE NEW FILM ARE ERASABLE, MAKING A SYSTEM USING THIS FILM REPROGRAMMABLE. THE SOVIETS ALSO APPEAR TO BE WORKING ON FILMS WITH MOLECULAR CONSTITUENTS THAT ARE ADAPTIVE AND SELF ORGANIZING. WITH THE ADDITION OF THIS CLASS OF FILMS, THE OPTICAL BRAIN COULD HANDLE MANY PROBLEMS REQUIRING DECISION MAKING FOR WHICH THE ALGORITHM CANNOT BE FORMULATED IN ADVANCE

U COMMENT: BIOELECTRONICS RESEARCH IN THE SOVIET UNION, THE UNITED STATES, AND ELSEWHERE COULD, IN THE NEXT DECADE OR SO, LEAD TO THE TECHNOLOGY THAT WOULD ENABLE VERY SMALL ARTIFICIAL NEURONS AND THEIR INTERCONNECTIONS TO BE PRODUCED. THESE NETWORKS WOULD BE SMALL ENOUGH TO RADICALLY REDUCE THE SIZE OF THE SOVIET BRAIN. A SMALLER BRAIN WOULD FIND MORE PRACTICAL USE FOR ROBOTICS, SMART WEAPONS, AND COMMAND-AND-CONTROL SYSTEMS

U COMMENT: FOR MANY REQUIREMENTS FOR ADAPTIVE, SELF LEARNING NEURON LIKE NETWORKS, A FULL SCALE BRAIN LIKE SYSTEM WITH 10EXP11 ELEMENTS WOULD NOT BE NEEDED. THE SOVIETS ARE CAPABLE OF BUILDING SMALL WORKABLE SYSTEMS WITH OFF-THE-SHELF OPTICAL OR ELECTRONICS TECHNOLOGY. AN EXAMPLE IS THE SHAPE ANALYZER MENTIONED IN THE 7 JANUARY 1983 ISSUE OF THIS PUBLICATION (AST-2660P-267-83). THE SOVIETS HAVE DEVOTED CONSIDERABLE EFFORT IN THE DEVELOPMENT OF THESE OPTICAL SIGNAL ANALYZERS. THESE ARE NEURON LIKE STRUCTURES AND EYE LIKE DETECTORS OF INTENSITY, COLOR, DEPTH, SHAPE ELEMENTS, AND VELOCITY. DETAILS OF THE RESULTS OF THIS WORK CAN BE FOUND IN THE BOOK NEUROBIONICS: THE ORGANIZATION OF NEURONLIKE ELEMENTS AND SYSTEMS, BY Y. N. SOKOLOV AND L. A. SHMELEV, PUBLISHED IN MOSCOW IN 1983. THIS BOOK DESCRIBES THE RESULTS OF EXPERIMENTS AND THEORETICAL INVESTIGATIONS PERFORMED BY THE AUTHORS AND USED BY THEM AS THE BASIS FOR A COURSE OF LECTURES THEY GAVE AT MOSCOW STATE UNIVERSITY.

U COMMENT: THE SOVIETS ARE ALSO CONDUCTING INNOVATIVE RESEARCH IN NEUROPHYSIOLOGY THAT COULD YIELD A BETTER UNDERSTANDING OF THE WAY THE BRAIN FUNCTIONS. THE RESEARCH OF A. G. BRAGIN AND O. S. VINOGRADOV AND OTHERS AT THE INSTITUTE OF BIOLOGICAL PHYSICS IS A CASE IN POINT. THIS TEAM HAS, FOR THE PAST DECADE, BEEN CONDUCTING RESEARCH THAT HAS ENABLED THEM TO REMOVE SECTIONS OF THE BRAIN FOR STUDY, HAVE THE SECTIONS SURVIVE AND, MORE RECENTLY, IMPLANT SECTIONS OF BRAIN FROM ONE SPECIES INTO ANOTHER

U COMMENT: THIS RESEARCH IS CONCERNED WITH THE FOLLOWING: 1. THE FUNCTION OF THE HIPPOCAMPUS AND CONNECTED STRUCTURES IN THE PROCESSING AND STORAGE OF INFORMATION (THE HIPPOCAMPUS IS THAT SECTION OF THE BRAIN THOUGHT TO BE CONCERNED WITH MEMORY). 2. SELF ORGANIZATION OF THE BRAIN STRUCTURES. 3. THE ABILITY OF BRAIN TISSUE TO CONNECT ITSELF TO A HOST SYSTEM IN A FUNCTIONAL WAY. 4. SURVIVAL OF BRAIN SECTIONS AFTER REMOVAL (THE SOVIETS HAVE BUILT AN EXPERIMENTAL CHAMBER FOR SURVIVING SECTIONS OF THE BRAIN).

* *

SEQUENCE NR: CXA85027099   USE█████████   ID: ⌐0571-90NOV20/14.11.14/A⌐⌐

SG1I

U COMMENT: THE IMPLICATIONS OF THIS RESEARCH GO BEYOND DESIGNING A BETTER ARTIFICIAL BRAIN.   THE SOVIETS, FOR EXAMPLE, ARE INTERESTED IN DEVELOPING SYSTEMS BASED ON THE INTERACTION OF REAL AND SYNTHETIC NERVOUS NETWORKS FOR WHAT THEY CALL NEUROCYBORGIZATION.   THIS SUBJECT AND RELATED TOPICS WILL BE EXPLORED IN DEPTH IN A FUTURE ISSUE OF THIS PUBLICATION.

C COMMENT: OF DIRECT MILITARY INTEREST, A DEVICE SUCH AS THE OPTICAL BRAIN, BASED ON NEURON NETWORKS, MIGHT BE ABLE TO SOLVE NONFORMAL PROBLEMS.   THIS IS A GREAT ADVANTAGE FOR PATTERN RECOGNITION, THE INTEGRATION OF SIGNALS FROM MULTIMODAL SENSORS, AND THE AUGMENTATION OF COMMAND DECISION MAKING.

U COMMENT: WITH PARALLEL PROCESSING, VARIOUS PROPERTIES OF AN IMAGE CAN BE TRANSMITTED ALONG DIFFERENT CHANNELS, I.E., SHAPE, COLOR, MOTION, ORIENTATION, ETC. RECOGNITION OF THE TARGET CAN BE PREDICTED AS VARIOUS PROPERTIES ARE INTEGRATED WITH THE MOVEMENT OF INFORMATION THROUGH SUCCESSIVE LEVELS OF THE NETWORK.   IN THE SAME WAY, INFORMATION FROM MULTIMODE SENSORS CAN BE INTEGRATED, I.E., OPTICAL, INFRARED, SEISMIC, CHEMICAL, ACOUSTIC, ETC.

U COMMENT: THE SOVIETS ARE ALSO INTERESTED IN SHORTENING THE TIME, IMPROVING THE EFFICIENCY, AND REDUCING THE STRESS IN MAKING COMMAND AND INDIVIDUAL COMBAT DECISIONS.   A BRAIN LIKE DEVICE WITH AN ALGORITHM MODELED AFTER THE WAY HUMANS THINK COULD HELP MEET THESE GOALS.