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EDITORIAL

COVER: Two Sud Aviation SE 3200 Frelon helicopters, powered by three Turbomeca free turbines delivering 812 shp. on takeoff, are shown in hovering configuration. Maximum speed of aircraft is reported at 131 kt. and cruising speed 124 kt. Prototype flights have been made above 13,000 ft. Although the aircraft first flew June, 1959, no preproduction orders have been received from the French government. West German Defense Ministry, however, has expressed interest in the French craft (AW Feb. 27, p. 35).

PICTURE CREDITS

Cover—Sud Aviation; 30—Convair; 32—UPI; 33, 109—USAF; 43—Horton & Horton; 45—Sud Aviation; 54, 55 (top)—Messerschmitt AG Augsburg; 55 (bottom)—NATO; 64—Plasmadyne Corp.; 81—FMA, Inc., Electronic Associates Inc.; 87—Aviation Week; 90—Rocketdyne; 93—Bristol Siddeley; 100—Beech; 103—Dassault; 112—Martin; 119—Grumman; 121—Armstrong-Whitworth.

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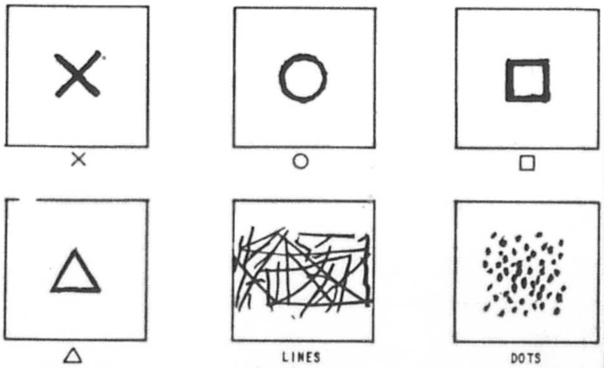
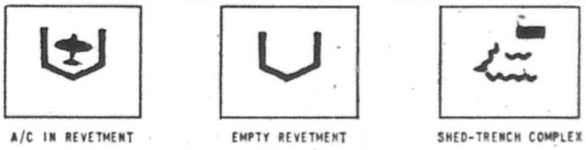


ACTUAL PATTERNS PROJECTED ONTO MARK I RETINA

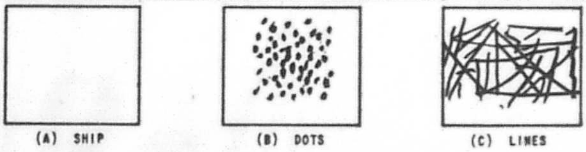
	STIMULI						DETECTION RATE	FALSE ALARM RATE
	X	○	□	△	LINES	DOTS		
PERCEPTRON TRAINED ON X	78/78	3/79	7/24	7/24	10/49	6/24	1.0	.17
PERCEPTRON TRAINED ON O	13/78	79/79	17/24	8/24	12/49	7/24	1.0	.29

SIMPLE targets shown were first used in recent experiments to evaluate possible use of Perceptron type machine to spot targets automatically in reconnaissance photos. Tests, conducted by Cornell Aeronautical Laboratory, showed 100% detection of such targets with only a moderate number of false alarms.



A/C IN REVETMENT	A/C ALONE	REVETMENT ALONE	SHED-TRENCH COMPLEX	DETECTION RATE	FALSE ALARM RATE
11/12	2/12	0/12	0/12	.92	.06

FREQUENCY OF "TARGET" RESPONSE



SHIP ALONE	SHIP IN CLUTTER		CLUTTER ALONE		DETECTION RATE IN CLUTTER	FALSE ALARM RATE
	LINES	DOTS	LINES	DOTS		
12/12	10/12	10/12	3/12	0/12	.83	.12

FREQUENCY OF "TARGET" RESPONSE

LATER experiments used pseudo-realistic targets shown above. Simple black-and-white images were used because of limitations in Mark I Perceptron retina. Machine was very successful in recognizing aircraft in revetment and in detecting ship despite presence of clutter, with only modest number of false alarms.

Perceptron Tested for Photo Analysis

By Philip J. Klass

Washington—Recent tests indicate that self-learning machines of the Perceptron type (AW July 4, p. 72) can be trained to recognize targets of interest in aerial reconnaissance photographs, easing a serious bottleneck to the effective use of meteorological and reconnaissance satellites.

Results of the tests, conducted by Cornell Aeronautical Laboratory under Office of Naval Research sponsorship using the Mark I Perceptron, were reported by CAL's Albert Murray here during a recent meeting of the American Society of Photogrammetry.

The problem of making effective use of the vast number of photographs obtainable from satellites is pointed up by the 23,000 photos produced by Tiros I meteorological satellite in its brief 2½-month period of operation.

Analysis of photos produced by a military reconnaissance satellite, such as Samos, to spot targets and other information of military value is estimated to require tens of thousands of man-hours for each hour the satellite spends over unfriendly territory.

Objective of the Office of Naval Research-sponsored tests was to evaluate the ability of a very elementary, modest-size machine to scan large quantities of photos, searching for a few kinds of objects, such as ships at sea or missile sites in the Arctic. This is considered only a starting point for more sophisticated machines which might locate special target shapes despite obscuring natural or man-made environment surrounding the target.

Test Conclusions

Based on the Mark I Perceptron tests, Cornell Aeronautical Laboratory scientists have reached the following conclusions:

- **Target recognition** is relatively easy and quite reliable when the machine is properly trained. This applies whether the target is alone or in company with other objects.
- **False alarm rate** can be high for forms which resemble the shape of a target unless the machine is given "negative training" to ignore such objects.
- **Machine is apt to be confused** if targets and similarly shaped non-target objects both appear on the same photograph.

From a practical standpoint, the difficulty in discriminating between targets and similarly shaped non-target objects is not a serious handicap. The major need for automation is to sort through hundreds of thousands of photographs which are of no meteorological or military value, picking out the tiny fraction of frames that are of potential value. These could then be analyzed by human operators.

The important factor is that the machine did not overlook any potential targets, and from this viewpoint the CAL test results are encouraging, Murray indicated.

In the initial experiment, CAL scientists exposed the Perceptron's photoelectric "eye" to "X's," circles, squares, triangles, random lines and random dots. (The "eye," or retina, consists of 400 photoelectric cells.) In order to conduct two tests simultaneously, the Perceptron's 240 association units (called A-units) were divided in half, in effect creating two separate Perceptrons each with 120 A-units. One of the machines was trained to identify "Xs" while the other was trained to recognize circles.

During the course of this experiment, the Perceptron's eye was exposed 78 times to the "X," 79 times to the circle, 24 times each to the square, triangle and random dots and 49 times to the random lines to determine how many times the one split machine could correctly identify the "X" and how often the other correctly could identify the circle. Also recorded were the numbers of "false alarms," i.e., when the machine(s) thought one of the other symbols was an "X" or a circle.

The machine trained to identify the "X" as a target and the other trained on circles both hit 100% in spotting every trained-target viewed. The machine trained to identify "X's" experienced a 17% false alarm rate, i.e., falsely identifying other shapes as "X's" 17% of the time, while the machine trained on circles had a false-alarm rate of 29% in these tests.

The machine trained on X-shaped targets had the most false alarms when exposed to the random lines, while the circle-shaped target-trained machine had the most difficulty in distinguishing between circles and squares.

Negative Training

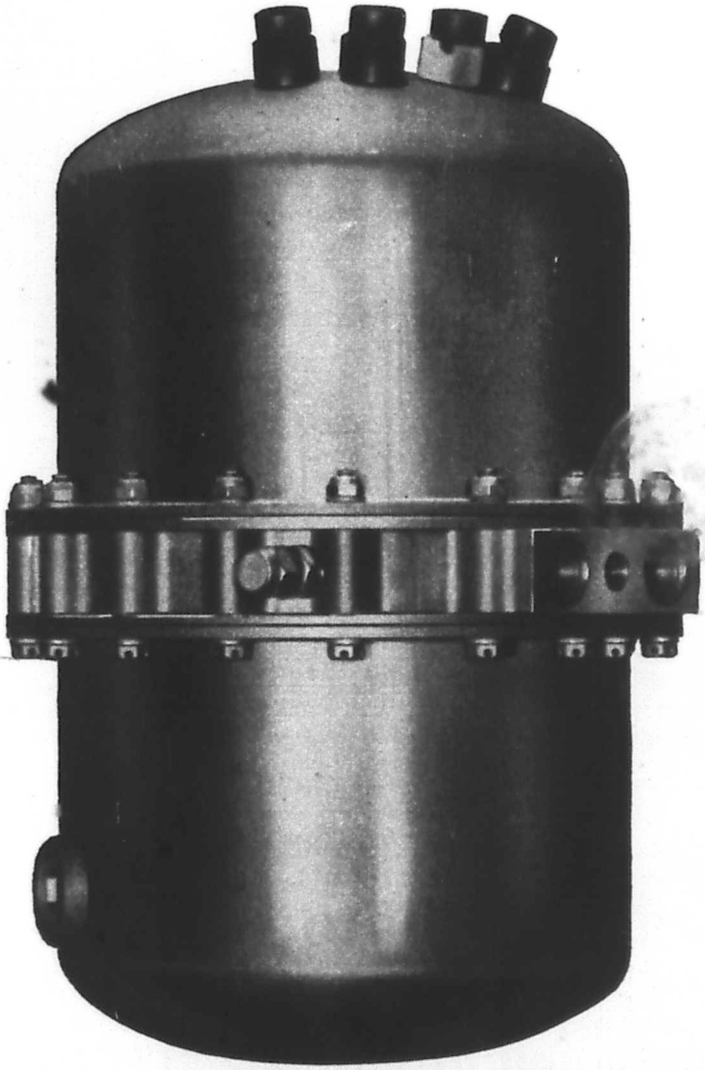
In the first experiment, neither of the machines was given any "negative training." That is, during the training period, the machine's A-units received only a "reward signal" when it correctly identified the proper shaped target; no "punishment" signal was given the A-units when it made an incorrect identification.

In the next experiment, a small amount of negative training was given the machine on some of the non-target shapes but only sketchy negative training on other non-targets, according to Murray. When the first experiments were repeated, the beneficial effect of the negative training was apparent in the reduced false-alarm rate.

However, another mode of operation was devised which gave an even more substantial reduction in the false-alarm rate. This mode is called the "four-fix look" mode. It has its human analogy in that people often take several looks at an object in a photograph before they are able to decide what it is, or is not.

In normal operation, as soon as the stimulus image is exposed to the Perceptron's retina, the machine is commanded to respond. But in the four-fix look mode, the retina is exposed to the image, then the image is shifted one retina photocell to the right, then one down and finally one to the left. Only after the machine is given these four looks is it commanded to respond and its ultimate response is calculated from the average of the net signal voltages delivered to the response unit (R-unit) from each image position. (For detailed description of Perceptron operation, see AW July 4, p. 72.)

A comparison of the value of negative-training and four-fix looks on target identification in CAL's tests showed the following. The use of four-fix looks, without any negative training, slashed the false-alarm rate of the X-trained



(NO NEGATIVE TRAINING)

		STIMULI						DETECTION RATE	FALSE ALARM RATE
		X	O	□	△	DOTS	LINES		
PERCEPTRON TRAINED POS. ON X	1-FIX	12/12	1/12	5/12	4/12	3/12	3/12	1.0	0.27
	4-FIX	6/6	0/6	0/6	1/6	0/6	0/6	1.0	0.03
PERCEPTRON TRAINED POS. ON O	1-FIX	3/12	12/12	12/12	4/12	5/12	4/12	1.0	0.47
	4-FIX	1/6	4/6	4/6	5/6	0/6	0/6	.7	0.33

FREQUENCY OF "TARGET" RESPONSES

(SOME NEGATIVE TRAINING)

		STIMULI						DETECTION RATE	FALSE ALARM RATE
		X	O	□	△	DOTS	LINES		
PERCEPTRON TRAINED POS. ON X	1-FIX	11/12	0/6	6/12	3/12	5/12	1/12	0.9	0.25
	4-FIX	6/6	0/6	0/6	0/6	0/6	0/6	1.0	0
PERCEPTRON TRAINED POS. ON O	1-FIX	0/6	9/12	4/12	3/12	1/12	4/12	0.8	0.20
	4-FIX	0/6	6/6	3/6	3/6	0/6	0/6	1.0	0.20

FREQUENCY OF "TARGET" RESPONSES

TO REDUCE false alarm rate, two techniques were successfully used. Negative training, in which machine is exposed to both wanted and unwanted shapes during training and "four-fix" in which machine gets four looks at image, each with image at a slightly different location on the retina. Latter, which has human analogy, was more successful.

machine in these tests from 27% to only 3%, without any deterioration of its 100% abaility to spot "X's." When combined with negative training, the X-trained machine continued to identify "X's" every time, and its false alarm rate dropped to zero.

The value of four-fix looks for the machine trained to identify circles was not quite so effective. With no negative training, the additional looks enabled the machine to reduce its false-alarm rate from 47% to 33%, but in so doing the machine's ability to identify circles dropped from 100% to 70%. With the combination of four-fix looks and negative training, the machine returned to 100% identification of circles with a still lower false-alarm rate of 20%.

Additional experiments conducted using pairs of shapes, one superimposed upon the other, tended to confirm the merit of multi-look over single-look exposure but showed mixed results for negative training. However, subsequent experiments indicated that the results of negative training might have been more favorable if a more extensive period of training had been used, according to Murray.

In another series of experiments, CAL used target shapes which more closely resemble those which a machine might be expected to detect. It was not feasible to expose the Perceptron directly to reconnaissance photographs because of the limitation inherent in the Mark I which originally was built only to demonstrate the principle of self-learning machines. The Mark I's retina has only 400 photo-cells and is designed to give only a "black" or "white" response, with no gray-scale shading.

For this reason, simple black-and-white sketches shaped like aircraft and ships were used in these experiments. In one trial, the Perceptron was exposed to four different images: an airplane, an airplane in a revetment, a revetment of the same shape without an aircraft, and a shed-trench complex. The machine was exposed to each sketch 12 times after having been given positive training for the revetment with aircraft image, and a small amount of negative training for the revetment without aircraft.

Example of Accuracy

In the experiments the machine correctly identified the aircraft in the revetment 92% of the time, falsely identified the aircraft alone 6% of the time, but was never misled by the revetment alone or the shed-trench complex.

In a similar experiment, intended to test ability to detect targets in the presence of clutter, a target shaped like the plan view of a ship was used. The machine was trained on the target image alone, but in subsequent tests was asked to spot the target when superimposed on a random clutter of dots or a random clutter of lines.

The Perceptron correctly spotted the target image 83% of the time when it was superimposed on either dot or line clutter. When the machine was exposed only to line clutter with no target present, it false-alarmed in 25% of the exposures, thinking that it saw a ship in the clutter. It had no such difficulty with the dot clutter, giving an over-all false-alarm rate of 12% for both types of clutter.

Cornell Aeronautical Laboratory scientists call the results of these, and other photo-intelligence experiments, "encouraging." These experiments have demonstrated considerable photo-interpretation ability inherent even in so small and simple a machine as the Mark I, they conclude. Laboratory and ONR-financed design studies for a Mark II Perceptron, with approximately 20 times as many A-units and nine times as many photo-cells in its retina, indicate it should be able to handle much more difficult photo-interpretation tasks.

Batteries Tested For Space Reliability

In first life-cycle tests on nickel-cadmium batteries at new Air Force-sponsored test facility in Dayton, approximately 25% of the cells failed after a total of 575 charge/discharge cycles, each consisting of 55 min. under charge followed by 35 min. under discharge. Remainder of the cells will be operated for a total of 6,000 cycles or until all have failed, whichever occurs earlier.

Tests were conducted by the Dayton-Inland Testing Laboratories of

NICKEL-CADMIUM BATTERIES undergoing high-temperature life-cycle (charge/discharge) tests at new Dayton-Inland Laboratories under Air Force sponsorship to determine their reliability for space vehicle use and basic causes of battery failures.