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APPLICATIONS OF FUZZY SETS TO REMOTE VIEWING ANALYSIS (U)

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I INTRODUCTION (U)

(U) Since the publication of results of the initial remote viewing (RV) effort at SRI International (SRI)*[1] two basic questions have remained in evaluating remote viewing data:

- What is the definition of the target?
- What is the definition of the RV response?

(U) The first attempt at quantitatively defining an RV response involved reducing the raw transcript to a series of declarative statements called concepts.[2] It was found that a coherent concept should not be reduced to its component parts. For example, a *small red VW car* would be considered a single concept rather than four separate concepts, *small, red, VW,* and *car.* Once a transcript had been "conceptualized," the list of concepts constituted, by definition, the RV response. The analyst rated the concept lists against the sites. Although this represented a major advance over previous methods, no attempt was made to define the target site. It was also extremely labor intensive and did not readily allow for rapid processing of RV data.

(U) In 1983, a procedure was developed to define both the target and response material.[3] It became evident that before a site can be quantified, the overall remote viewing goal must be clearly defined. If the goal is simply to demonstrate the existence of the RV phenomena, then anything that is perceived at the site is important. But if the goal is to gain specific information about the RV process, then possibly specific items at the site are important while others remain insignificant.

(U) In 1984, work began on a computerized evaluation procedure, which underwent significant expansion and refinement during 1985.[4] The mathematical formalism underlying this procedure is known as the "figure of merit" (FM) analysis. This method is predicated on descriptor list technology, which represented a significant improvement over earlier "conceptual analysis" techniques, both in terms of "objectifying" the analysis of RV data and in increasing the speed and efficiency with which evaluation can be accomplished. These techniques were based upon the pioneering work of Honorton et al. to encode target and response material in accordance with the presence or absence of specific elements.[5]

*(U) References may be found at the end of this report.

(U) It became increasingly evident, however, that this particular application of descriptor lists was inadequate in providing discriminators that were "fine" enough to describe a complex target accurately; it was also unable to exploit fully the more subtle or abstract information content of the RV response. To decrease the granularity of the RV evaluation system, therefore, the technology would have to evolve in the direction of allowing the analyst a gradation of judgment about target and response features, rather than the hard-edged (and rather imprecise), all-or-nothing binary determinations. A preliminary survey of various disciplines and their evaluation methods (spanning such diverse fields as artificial intelligence, linguistics, and environmental psychology) revealed a branch of mathematics, known as "fuzzy set theory," which provides a mathematical framework for modeling situations that are inherently imprecise.

(U) During FY 1986 and FY 1987, a fuzzy set implementation of remote viewing analysis was developed.[6,7] The primary application of this new technology, however, was to create an objective measure for target orthogonality. The orthogonal targets were then used in rank-order judging.

(U) During FY 1988, the analysis task was to determine appropriate parameters for fuzzy set remote viewing analysis. To accomplish this task, SRI reanalyzed the RV data collected during FY 1987, trimmed the *National Geographic* magazine target pool, and explored various ways to encode RV data in an entropy formalism.*

*(U) This report constitutes the deliverable for Objective F, Task 1.

II TECHNICAL DISCUSSION (U)

A. (U) Retrospective Analysis

(S/NF) We have reanalyzed all of the remote viewing experiments conducted during FY 1987 that used *National Geographic* magazine targets. There were a total of 292 sessions from the tachistoscope, real-time versus precognition, and hypnosis experiments. Using an overall p-value < 0.05 as a definition of statistical evidence of RV, only the real-time versus precognition experiment failed to meet that criterion.

(S/NF) During FY 1987, the analysis of these data used a subjective rank-order technique. For each RV response, the intended target and 6 decoys were ranked in order from most to least correspondence. The combined average sum-of-ranks was 3.781, where the expected average was 4.00 ($z = 1.87$; $p \leq 0.031$). Thus, even including the real-time versus precognition experiment, the total RV effort for FY 1987 showed statistical evidence of an information transfer anomaly.

(S/NF) It is possible that a mechanism other than psychoenergetics could account for this overall result. Suppose that analysts tended to rank the target packs in order of complexity--the most complex first, the least last. That is to say, a target with an abundance of elements would have more correspondence with any response, psychoenergetically mediated or not. To examine this hypothesis, complexity was defined as the total number of target elements such that their membership (in the target fuzzy set) was non-zero.* Two distributions were then constructed:

(1) The distribution of complexities for the targets ranked first by the analyst

(2) The distribution of complexities for the correct target regardless of rank.

(S/NF) Figure 1 shows these two distributions. The black histogram clearly demonstrates a bias ($X^2 = 11.30$, df = 6; $p \leq 0.08$) on the part of the analysts to favor the most complex target as the best match to a given response. This is to be expected, in that the instructions to the analysts are to find the *best* match between target and response. Thus, especially for noisy data, it is not surprising to find such a bias. On the other hand, the complexity distribution shows no

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*(U) The universe of elements for the target fuzzy sets was described during FY 1987,[7] but is repeated here in the Appendix.

(S/NF)

such bias for the intended target ($X^2 = 9.29$, df = 6; $p \leq 0.16$). In other words, since the intended target is chosen by a random number generator, the cross-hatched histogram is a simple test of the randomization algorithm. To test the null hypothesis that the proportions are the same in the two distributions, a chi-square was computed where the expected value in each cell was the row-total times the column-total divided by the grand-total. The proportions are significantly different for these distributions ($X^2 = 15.35$, df = 6; $p \leq 0.018$). Thus it is unlikely that judging bias in favor of the most complex target can account for the overall significant evidence of RV during FY 1987.

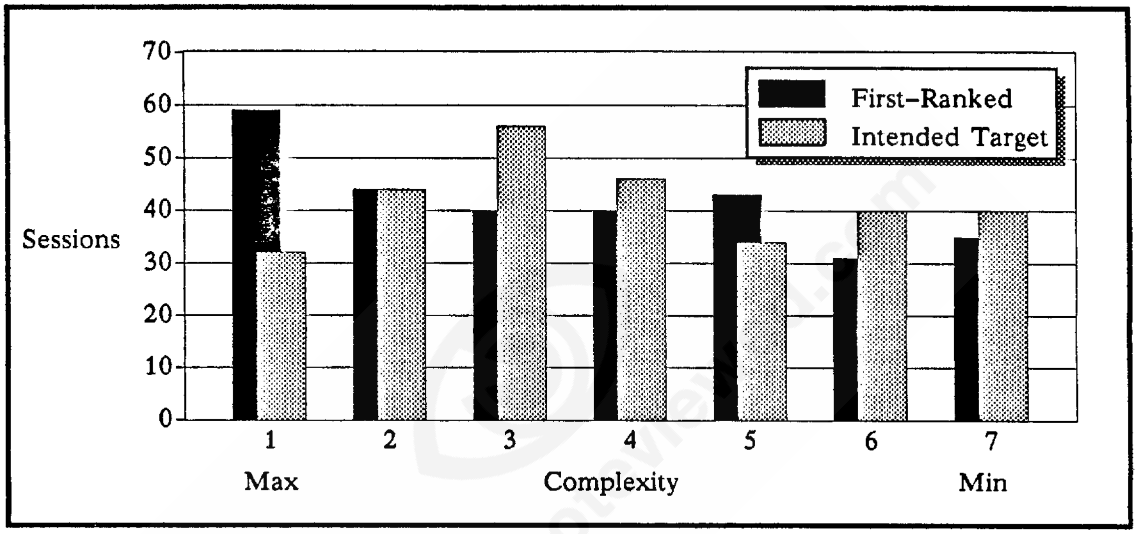

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FIGURE 1 (U) COMPLEXITY DISTRIBUTIONS FOR FIRST-RANKED AND INTENDED TARGETS

B. (U) Target Pool Reduction

(U) To provide a more manageable target pool for rank-order judging, we reduced the original *National Geographic* magazine target pool from 200 to 100 targets. The fuzzy set approach, in conjunction with cluster analysis, was used to produce 20 sets of 5 orthogonal targets. These sets were "fine tuned" by visual inspection to provide the best possible target sets. Approximately 20 percent of the targets required changing. The set of 100 targets was photographed and duplicated to form to identical target pools, one for analysis purposes only and the other for target purposes only. Separating these functions into two separate pools ensured that there could be no inadvertent handling cues (i.e., the experiment team "marking" the intended target so the analyst could recognize it).

C. (U) Entropy Encoding

(U) One of the most pressing problems in remote viewing, one which must be solved before any basic models can be developed, is determining the quantitative amount of information that is transferred during the procedure. There have been a number of attempts to quantify the information content in natural scenes in the past, but none of them appeared to work as a reasonable description of either the target or the response.

(U) One approach that has been tried in the past is to define an entropy-like measure for the elements of a fuzzy set.[8] Unfortunately, these approaches assume that some estimate of a "random" fuzzy set can either be assumed or calculated. In remote viewing terms, this amounts to knowing how a viewer might respond in a session in which there was no defined target. In free-response experiments, this is referred to as a response bias. Response biases are difficult to measure, and are very strong functions of time.

(U) To obtain an estimate of the average response bias of a given viewer during an RV series, we modified an earlier attempt. Assuming all response errors are due to bias, we define, for a given viewer, a bias fuzzy set, B, whose elements and membership values are defined by

$$\mu_k(B) = \frac{1}{N}\left[\sum_{j=1}^{N}\mu_{k,j}(R) - \sum_{l=1}^{N}\mu_{k,l}(T \cap R)\right] .$$

In the general case, the $\mu(X)$ notation indicates that the μ-values are from the set X, and T and R are the target and response sets, respectively. In words, the above relationship is the total response in a series of N trials (for a given element) minus that part of the response that was correct (i.e., possessed some overlap with the intended target). Each element, k, in B, represents the average value for the response being incorrect, or, ostensibly, a result of bias. (See the Appendix for the universe of elements, k).

(U) There are a number of ways in which this bias set can be used. One is to simply reduce the assigned (by the analyst) μ-values by a percent equal to their associated value in B to account for the bias contribution,

$$\mu_k(R') = \mu_k(R)(1 - \mu_k(B)).$$

For example, if the bias membership value for the roads-bit was 0.15, the transformed value would be (1.0 − 0.15) times the assigned value, or a 15 percent reduction of the assigned value. R' represents the adjusted value (by the average bias) for a response, R.

(U) For the first attempt at using *R'* to obtain an estimate of the accurate information transferred during a remote viewing experiment, we used basic information theory. In the theory, entropy is defined as a measure of uncertainty. The more uncertain, the larger the entropy. Correspondingly, complete certainty implies zero entropy. In symbols, a formal definition of entropy[13] for a fuzzy set is given as

$$H(X) = -\sum_k \mu_k(X)\log_2(\mu_k(X)) - \sum_k (1-\mu_k(X))\log_2(1-\mu_k(X)) \quad .$$

(U) If the usual probabilistic interpretation of entropy is to be adopted, then we must scale the μ-values to the interval [0.5,1]. The maximum uncertainty about a given bit is a μ-value of 0 (assigned by an analyst). If this value is shifted to 0.5, then H(X) is a maximum.

(U) The most uncertain response that a viewer can contribute is a blank page. All the assigned μ-values would be zero; the transformed values would be 0.5. If we consider the target set to be an α-cut of the target fuzzy set *T*, we define the maximum entropy possible for a response, H_0, as follows:

$$H_0 = -\sum_{k(target\ bits)} 0.5\log_2(0.5) \quad - \sum_{k(target\ bits)} 0.5\log_2(0.5) \quad = \#\text{ of target bits}.$$

For any non-null response, the entropy is defined as

$$H(R') = -\sum \mu_k(T \cap R')\log_2(\mu_k(T \cap R')) - \sum (1-\mu_k(T \cap R'))\log_2(1-\mu_k(T \cap R')).$$

The sums in *H(R')* are over all bits in *T* or *R'*. It is important to realize that the primed values in *R* are used, so *H(R')* accounts for a possible response bias. Finally, the information perceived (judged) in an RV session is defined as the difference between the maximum uncertainty of a response and its observed uncertainty. In symbols:

$$\Delta H(R') = H_0(R') - H(R') \quad .$$

(U) In order to test this and other ideas, it was necessary to have a database of encoded targets and responses. Thus, all of the responses for the tachistoscope experiment were coded in the fuzzy set representation using the universe of elements shown in the Appendix.

(U) To determine whether such an information encoding made sense, it was important to develop a criterion to define success. Since we could use the above formulation for the actual response, the modified (by the bias) responses, or a set of randomly assigned cross-matches

(U)

(i.e., responses assigned to targets that were not the intended target for the session), we were able to explore a number of options. If the information channel is not saturated, then it is reasonable to assume that the more information available in the target, the more information could be received via remote viewing. The criterion that was adopted was that the information calculated from a set of randomly selected cross-matches could not show significant correlations with the complexity (defined by the sigma count) of the associated targets.

(S/NF) Unfortunately, this method failed. A strong correlation was found between the cross matches and target complexity. In retrospect, the problem is obvious. Even using the modified responses, the probability of a match with a random target increases with target complexity (i.e., the more that is said, the more likely that there is a match to a random target).

(S/NF) We explored a number of different variations on the above formalism. To date, however, we have been unable to arrive at an appropriate formulation that meets the above or other criteria for a measure of information transfer during remote viewing experiments.

III CONCLUSIONS AND RECOMMENDATIONS (U)

(S/NF) It is extremely likely that there is an even more fundamental reason why the various procedures failed as a measure of information transfer during remote viewing. The elements from which the target and response sets are drawn are not of equal weight in information space. For example there is considerably more information (in any sense of that term) contained in an element such as church compared to an abstract element such as horizontal lines. Yet in this first attempt, the μ-values were all weighted equally.

(U) One direction that deserves exploration is limiting the target descriptions (by the weighting factors for each element in the fuzzy set) to sets of targets that appear to have constant "information" content. This might allow for a more systematic search for an appropriate information representation.

(U) Another problem was that the most uncertainty in a response was assumed to be a blank page. In the final days of FY 1988, Dr. L. Gatlin, a specialist in biological information systems, suggested that we approach the problem from a different point of view. The most uncertain situation is that in which a viewer is completely driven by his/her own response biases. Thus, H_0 should be calculated from the bias set, B, or something like it.

(U) It is very important to continue along these lines. Until a meaningful encoding of the information transferred during remote viewing experiment is found, there is little hope of success for quantitative modeling. We recommend that a consultant be found who is a specialist in applying information theory to natural scenes and natural language.

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APPENDIX (U)

UNIVERSE OF ELEMENTS FOR TARGET AND RESPONSE FUZZY SETS (U)

(This Appendix is Unclassified)

CONCRETE DESCRIPTOR LEVELS I

Experiment: ______
Trial: ______
Response: ______
Coder: ______
Viewer: ______

LEVEL	SINGLE STRUCTURES	SUBSTRUCTURES
10	1 ☐ fort 2 ☐ castle 3 ☐ palace 4 ☐ church (other religious buildings, monastery) 5 ☐ mosque 6 ☐ pagoda 7 ☐ coliseum (stadium, amphitheater, arena)	
9	8 ☐ bridge 9 ☐ [dam (lock, spillway)]	10 ☐ boats (barges) 11 ☐ pier (jetty) 12 ☐ [motorized vehicles (cars, trucks, trains)] 13 ☐ column 14 ☐ spire (minaret, tower) 15 ☐ fountain 16 ☐ fence 17 ☐ arch 18 ☐ wall (e.g., the Great Wall) 19 ☐ monument
8		20 ☐ roads

CONCRETE DESCRIPTOR LEVELS II

Experiment: ______
Trial: ______
Response: ______
Coder: ______
Viewer: ______

LEVEL	SETTLEMENT	ELEVATION	LAND/WATER INTERFACE	NO WATER OR VEGETATION	VEGETATION	AMBIENCE/ FUNCTION
7			21 ☐ port (harbor) 22 ☐ [oasis]		23 ☐ agricultural fields (orchards)	24 ☐ industrial 25 ☐ recreational 26 ☐ religious 27 ☐ mechanical 28 ☐ technical 29 ☐ agricultural 30 ☐ commercial 31 ☐ wilderness 32 ☐ urban 33 ☐ rural (pastoral) 131 ☐ historical (archaeological)
6	34 ☐ ruins (incomplete buildings)	35 ☐ mesa (plateau)	36 ☐ waterfall 37 ☐ glacier 38 ☐ canal (channel, manmade waterway)	39 ☐ desert	40 ☐ forest 41 ☐ jungle 42 ☐ swamp (marsh)	
5	43 ☐ isolated settlement 44 ☐ town (village) 45 ☐ city	46 ☐ single peak 47 ☐ hills (slopes, bumps, humps, mounds) 48 ☐ mountains 49 ☐ cliff(s) 50 ☐ [plain, delta] 51 ☐ valley (cleft, gully, irreg. depression) 52 ☐ canyon 53 ☐ [crater, bowl-shape, regular depression]	54 ☐ unbounded large expanse of water (ocean, sea) 55 ☐ completely bounded expanse of water (lake, pool, pond) 56 ☐ partially bounded expanse of water (bay) 57 ☐ island 58 ☐ river (stream, creek) 59 ☐ coastline		60 ☐ vegetation (trees)	

ABSTRACT DESCRIPTOR LEVELS I

Experiment: ______
Trial: ______
Response: ______
Coder: ______
Viewer: ______

QUALITIES

LEVEL	COLOR	OTHER VISUAL	IMPLIED TEXTURE	IMPLIED TEMPERATURE	IMPLIED MOVEMENT	AMBIENCE
4	61 ☐ yellow	71 ☐ shiny (reflective)	80 ☐ smooth	85 ☐ hot	89 ☐ flowing	91 ☐ congested (cluttered, dense, busy)
	62 ☐ orange	72 ☐ [gold]	81 ☐ fuzzy	86 ☐ cold (snow, ice)	90 ☐ other implied movement	92 ☐ serene (peaceful, unhurried, unfrenetic)
	63 ☐ red	73 ☐ [silver]	82 ☐ grainy (sandy, crumbly)	87 ☐ humid		93 ☐ closed in (claustrophobic)
	64 ☐ blue	74 ☐ [chrome]	83 ☐ rocky (ragged, rugged, jagged, rubbled, rough)	88 ☐ dry (arid)		94 ☐ open (spacious, vast, expansive)
	65 ☐ green	75 ☐ [copper]	84 ☐ striated			95 ☐ ordered (aligned)
	66 ☐ purple (pink)	76 ☐ obscured (fuzzy, dim, smoky)				96 ☐ disordered (jumbled, unaligned)
	67 ☐ brown (beige)	77 ☐ cloudy (foggy, misty)				
	68 ☐ black	78 ☐ old				
	69 ☐ white	79 ☐ weathered (eroded, incomplete)				
	70 ☐ grey					

ARCHETYPES

LEVEL	STRUCTURE	ELEVATION	INTERFACE	UNIQUENESS	AMBIENCE
3	97 ☐ building(s) (structure(s))	98 ☐ rise (vertical rise as well as slope)	100 ☐ light/dark areas (big swaths)	104 ☐ single (or central) predominant feature	106 ☐ manmade (or altered)
		99 ☐ flat	101 ☐ boundaries	105 ☐ odd (or surprising) juxtaposition of elements	107 ☐ natural
			102 ☐ land/water interface		
			103 ☐ land/sky interface (horizon)		

ABSTRACT DESCRIPTOR LEVELS II

Experiment: ______
Trial: ______
Response: ______
Coder: ______
Viewer: ______

2-D & 3-D GEOMETRIES

LEVEL	RECTILINEAR FORMS	CURVILINEAR FORMS	MIXED FORMS	IRREGULAR FORMS	REPEAT MOTIF
2	108 ☐ rectangle (square, box)	112 ☐ circle (oval, sphere)	114 ☐ cylinder	117 ☐ irregular forms (irregular features)	118 ☐ repeat motif
	109 ☐ triangle (trapezoid, pyramid)	113 ☐ [torus]	115 ☐ cone		
	110 ☐ other polygonal (> 4 sides: hexagon, octagon, etc.)		116 ☐ semicircle (hemisphere, dome)		
	111 ☐ cross-hatch (grid)				

1-D GEOMETRY

LEVEL	1-D GEOMETRY			VISUAL CORRESPONDENCE
1	119 ☐ stepped	127 ☐ arc (curve)	130 ☐ meandering curve	☐ rank order fraction
	120 ☐ parallel lines	128 ☐ wave form (ripples)		
	121 ☐ vertical lines	129 ☐ spiral		
	122 ☐ horizontal lines			
	123 ☐ diagonal lines			
	124 ☐ V-shape			
	125 ☐ inverted V-shape			
	126 ☐ other angles			