Mon July 16, 1956. T.M.

$\boxed{SN}$ There should be a greater attempt in this elementary T.M. work, to stick as close as possible to intuitive methods of learning. T.M. should be simply an attempt to <u>explicate</u> one's intuitive concepts.

E.G. ① In "=" we would <u>like</u> T.M. to realize that $\overset{|}{|}$ and $\overset{\circ}{\circ}$ are somehow related to "=", but there is no reason for T.M. to pick such a remote "cause" when $\overset{|}{\sqcup}$ and $\overset{\circ}{\square}$ are sufficient.

② When "~" is given, again, we would like T.M. to realize $\overset{|}{\circ}$ and $\overset{\circ}{|}$ are assoc. with "~". While this is not <u>too</u> improbable, tetragrams are still probably easier (intitively).

③ When $\oplus$ (≡ βΣ) comes around, T.M. should be ready to realize that th. isolated signs =, ~, $\oplus$, condition th. operations occuring <u>near them</u> — or even in just th. same example.

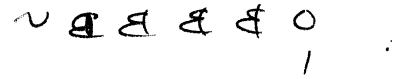
At this point th. foll. **epist. rule** comes up: "If something happends that was unforseen, then look for the things near th. unforseen event that are "unusual". They are good guesses for th. "causes" of th. unforseen events. A good def. of "unusual" has been gvn. before: essentially, an event is "unusual" if it doesn't conform to th. abss. that most examples <u>have</u> conformed to up to th. present time.

It mite be well to formulate this in a form for use with elementary Math T.M. Suppose one has a bunch of abss. that are very U. in prediction — that one's score is <u>very</u> hy. Then one gets a few new examples in which predictions are

α66

T.M.

However, it may be said that if we have a sufficiently long ~ or = problem, it will take less time for T.M. to learn th. tetragrams, than to carry on th. "contagion-process" of learning trigms like



⑥ Say T.M. has learned tetragrams. (The formation of trigrams gone thru on α61 to α63 is mainly for illustration of methods of developing ntpsts. by inversion; and th. use of "neigboring" strs)

Next try βΣ. (≡ ∨) (≡ ⊕)

$\oplus \begin{matrix}1&0&0&0\\1&1&0&1\\1&1&0&\boxed{1}\end{matrix}$, $\oplus \begin{matrix}0&0&1&1\\0&1&1&1\\0&\boxed{1}&1&1\end{matrix}$, $\oplus \begin{matrix}1&1&0&1\\1&0&1&0\\1&1&\boxed{1}&1\end{matrix}$ etc.

Th. mongrams now become of some U, since 1's occurre more frequently than 0's.

If □'s are ~~[illegible]~~ put in th. bottom line only, than $\overset{1}{\square}$ become of hy U, for this particular problem, also "=" but it is of not much U. in ~ — so on th. average, $\overset{1}{\square}$ does much good.

Th. tetragrams

$\begin{matrix}1&1\\1&\square\end{matrix}$, $\begin{matrix}0&1\\0&\square\end{matrix}$, $\begin{matrix}\blacksquare&1\\\square&1\end{matrix}$, $\begin{matrix}\blacksquare&0\\\square&0\end{matrix}$ are of hy U. with 100% correctness.

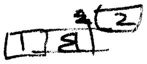
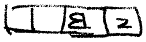
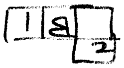
They do not, however, ~~predict~~ fit all cases.

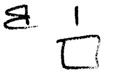
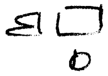
Th. tetragrams $\begin{matrix}1&\square\\0&1\end{matrix}$, $\begin{matrix}0&\square\\0&0\end{matrix}$ etc. are of ~~[illegible]~~. lower U. However, they can be salvaged by adding th. space, to obtain pentagrams:

$\begin{matrix}S&\\1&\square\\0&1\end{matrix}$, $\begin{matrix}&S\\0&\square\\0&0\end{matrix}$ etc.

T.M.

of these, only

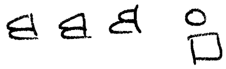
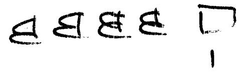
, ,  are of any V, so we retain them: they produce

≠ ∼ , = , etc.

~~[illegible]~~ This fact strengthens th. aprip of M, $\overset{c}{\hat{X}}$ D, as well as its V.

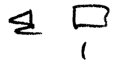
Similarly, we try neighboring strs. to  et. al, and obtain

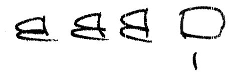
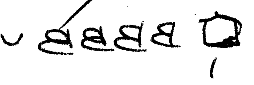
∼ , etc.

We get ∼  and = 

by ~~∼ = opa~~ similar operations each time.

$\boxed{5N}$ At this point, we would like T.M. to learn that if we ~~can go from~~ it is desirable to go from

∼  to ∼  to ∼ ,

it should be much more immediately desirable to try ∼  and ∼ 

This seems to make ~~[illegible]~~ expedient, T.M's ability to use sets of sets of sets....

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⑤ ~~[illegible]~~ Whether T.M. uses tetragrams or trigrams to predict = and ∼, will depend on th. relative aprip. attenuations assigned to th. various operations used in forming them. α64

T.M.

$\underset{\text{str.}}{\boxed{1|2}} \times \Big[\underset{\text{mongram set}}{(=, \sim)} \underset{\text{cart. product}}{\overset{c}{\times}} \underset{\text{digm set;}}{\left(\overset{1}{\blacksquare}, \overset{\circ}{\blacksquare}, \underset{1}{\square}, \underset{\circ}{\blacksquare} \right)} \Big]$

$S_1 \quad \times \Big[M_1 \quad \overset{c}{\times} \quad D_1 \Big]$

S_1 is of hy aprip. – as initial str. that T. M. starts with.

Th. trigm set $M_1 \overset{c}{\times} D_1$ was obtained in th. foll. way:

$\boxed{1|2}$ was mult. by th. cart product of

$\left(\underbrace{\overset{1}{\square}, \overset{\circ}{\square}, \underset{1}{\square}, \underset{\circ}{\square}}_{\text{are digms that have had hy U in th. past}}, \underbrace{=, \sim, 1, 0}_{\text{are monogms, and are always of hy U.}} \right)$ with itself.

Th. result was a set of 128 trigrams. of these, only 32 ever occure, only 24 contain $\square$. of these 24, ~~only~~ 8 are of hy U. They are

except for extanious ambiguous trigrams

Note: $\boxed{1|2} \times \left(=, \overset{1}{\square}\right) \to \left(=\overset{1}{\square}, =\underset{\square}{1}\right)$

In general, if in multiplying a str. times an ntpl, th. result is ambiguous, then <u>all</u> of th. ambiguous ~~elements~~ resultants should be retained.

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since $S_1 \times (M_1 \overset{c}{\times} D_1)$ = an ngmst of hy U, and S_1 is of hy aprip, then $M_1 \overset{c}{\times} D_1$ is of hy aprip.

we try strs. <u>near</u> S_1 and mult. them by $M_1 \overset{c}{\times} D_1$ to obtain trial trigmsts.

some strs "near" $\boxed{1|2} = S_1$

The inability is due to th. fact that e.g. $\overset{1}{\boxed{1}}$ and $\overset{0}{\boxed{0}}$ cannot be, in this method, members of th. same categorization group. In th. present case, it <u>would</u> be nice to have $\overset{1}{\boxed{1}}$ and $\overset{0}{\boxed{0}}$ members of th. same cat. gp. — since this would give something closer to th. idea of "equality" but this is not <u>essential</u> yet.

It <u>should</u> be looked into <u>soon</u> however. We mite make $\square$ part of th. specification of a str. — then

$$\overset{1}{\boxed{1}}\;,\;\overset{0}{\boxed{0}} \equiv \underset{\text{str.}}{\boxed{\begin{smallmatrix}1\\ \boxed{\;}\end{smallmatrix}}} \times \underset{\substack{\text{monogram set.}\\ \equiv 1 \text{ tuple set.}}}{\underbrace{0, 1}}$$

---

④ $\sim\begin{smallmatrix}1&0&0&1\\0&\boxed{1}&1&0\end{smallmatrix}$, $\sim\begin{smallmatrix}0&\boxed{0}&1&1\\1&1&0&0\end{smallmatrix}$, $\sim\begin{smallmatrix}1&0&1&\boxed{0}\\0&1&0&1\end{smallmatrix}$ is given.

with associated problems. This makes all digms useless. Trigrams are tried.

$=\begin{smallmatrix}1\\ \square\end{smallmatrix}$, $=\begin{smallmatrix}\square\\ 0\end{smallmatrix}$, , $\sim\begin{smallmatrix}\square\\ 1\end{smallmatrix}$ etc. are **U**.

However, most cases are not predictable by compact Trigrams.

ⓐ Tetragrams work in <u>every</u> case!

e.g. $\begin{smallmatrix}1&0\\1&\square\end{smallmatrix}$, $\begin{smallmatrix}0&\square\\1&1\end{smallmatrix}$, $\begin{smallmatrix}1&1\\ \blacksquare&0\end{smallmatrix}$ etc.

ⓑ **It is possl. to develope** trigrams like

$=\begin{smallmatrix}\text{ᗺ}&1\\ &\boxed{\blacksquare}\end{smallmatrix}$, $=\begin{smallmatrix}\text{ᗺ}&\text{ᗺ}&\boxed{\blacksquare}\\ &&0\end{smallmatrix}$ etc. in th. foll. way:

This method involves more operations, but th. result seems, intuitively, more desirable.

Th. ngm set

$=\begin{smallmatrix}1\\ \square\end{smallmatrix}$, $\sim\begin{smallmatrix}\square\\ 0\end{smallmatrix}$ et. al, can be factored into

T.M.

from ∝58.40 :

More detailed descriptions of Math T.M.'s response to a trg. sequ. up to <"+" with carry line>.

① T.M. is first fed a set of examples like

$= \begin{array}{cccc}1&0&0&1\\ \boxed{1}&0&0&1\end{array}$; $= \begin{array}{cccc}0&1&\boxed{0}&1\\ 0&1&0&1\end{array}$; $= \begin{array}{cccc}1&1&1&0\\ 1&1&1&\boxed{0}\end{array}$ etc.

The problems are of Th. form $= \begin{array}{cccc}1&1&0&1\\ 1&\square&0&1\end{array}$

② T.M. start off by making digit ~~freq.~~ freq. counts and using them for prediction. ~~If Th size of the input array is 10×7, $\frac{61}{70}$ is freq. of **S**~~ ~~$\frac{1}{70}$ " " " **=**~~

(**S** = blank space)

~~$\frac{4}{70}$~~ .5 is freq. of 0 } since □ is never put around = or **S**.
~~$\frac{4}{70}$~~ .5 is freq. of 1

Monograms are denoted by □. ~~Fr~~ Frequencies determine a 4-component vector

③ Predictions are very poor, so T.M. tries digrams next. Some digrams:

$1\square$, ${}^{1}\square$, $\overset{1}{\square}$, $\square^{1}$, $\square 1$, $0\square$, ${}^{0}\square$, $\overset{0}{\square}$, etc.

Each digm. gets a prediction vector assigned to its □, thru frequ. counts.

Only Th. digms $\overset{1}{\square}$, $\overset{0}{\square}$, $\underset{1}{\square}$, $\underset{0}{\square}$ are of <u>any</u> U in prediction. Since They have a prediction efficiency of 100%, <u>no</u> <u>other</u> digms or trigrams are introduced, untill ~ problems arogn.

$\boxed{\text{SN}}$ Th. use of □ or $\overset{1}{\square}$ e.g. as monograms or digms., gives T.M. a serious instability, but we will let This ride for a while. ∝61

Sun July 15, 1956 T.M. α 59

Monte Carlo searches: from X 974 and α 46 (also more previous work.)

On α 45 we seem to have worked cases 3) and 4) incorrectly

case 3) is worked exactly and correctly on th. bottom of x972 and top of x973. "n trials" is correct.

For 4) th. method of th. top of x973 seems rite, but it conflicts with the corrected method of α45 for α45: If the i^{th} element in th. set is correct, then th. expected no. of trials is

$$1\cdot p_i + 2(1-p_i)p_i + 3(1-p_i)^2 p_i \cdots$$

$$= p_i \Sigma\, x\,(1-p_i)^{x-1} = p_i\left(\frac{1}{(1-(1-p_i))^2}\right) = \frac{1}{p_i}$$

Since th. i^{th} element is correct p_i of th. time, th. expected no. of trials for all time is

$$\Sigma\, p_i \frac{1}{p_i} = n.$$

.25 On th. other hand: from x973.02

th. proby of getting th. rite choice in th first trial is

Σp_i^2.

Th. proby of getting it on th. second trial is

$(1 \Sigma p_i^2)\Sigma p_i$ } N

This is the error. Th. proby. distrib. for th. second choice is not ~~[illegible]~~ th. same as th. first, since knowing we failed th. first time makes it more likely that th. "true" case is more toward th. lower p_i's.

α57.30 Tues July 10, 1956

.01 Criticisms; cont.

4) Shannon suggested that they be gn. a chance to pick their own problem for this T.M., to gard v.s. ad-hockness - say a sq. root problem, and to do a "hand simulation of it".

List imp. abs. that T.M. ought to have:

1. carry line problem soln.
2. set of set of sets ··· etc.
3. to extrapolate th. str 1 8 8 8 ··· 2, out into th. → direction, an arb. distance.
4. Will T.M. think of trying commutativity on various operators? i.e. in 1+2=3 to give 2+1=3 hyer aprip than 1+3=2.
5. Teaching T.M. to fill in <1 ☐ ; 6. ommission of ☐.

SN On B.G. : Th. "soln." that consists ~~ing~~ of ~~in~~ taking th. "Best" categorization group that an event belongs to, isn't too bad: In fact it is as general a soln. to th. problem as any. Th. gp. that is th. Boolean product of all th. gps. an event belongs to, will, in general, be of hy apri. U, and be th. "Best" gp. available. Th. trouble is, th. evaluation of th. prediction params. of a gp. as a function of th. ~~prediction~~ params. of th. ~~elem~~ gps., n tpsts and strs. from which it was formed, is as difficult as th. B.G. problem! However, this latter would have to be done anyway, regardless of what sort of B.G. soln. was used.

Present approach: Just work on th. devising of "new gps from old" problem, with a little attention to the ~~other~~ expected amount of attenuation of aprip with th. no. of operations performed.

A running account of T.M.'s battel with a Tng. sequ. is on. X939.27 ff. comments up to X957.22 where it is decided that I ought to be able to do up to "+" with carrey line, and I should "consolidate gains".

A more detailed description of th. Tng. sequ. up to "+" will follow - on α60.

.40

α59

in which 01 occures. If one has an infinitely large discrete universe, or a ~~continuous~~ finite the continuous one, there are, indeed, an ∞ of poss/. states of th. universe in which 01 occures.

Also, I think that in th. case of learning

$$= \begin{matrix} 1 & 0 \\ 0 & 1 \end{matrix} \quad \begin{matrix} 11100\cdots1\cdots0\ 0\ 1\ 0\ 0 \\ 11100\cdots1\cdots0\ \square\ 1\ 0\ 0 \end{matrix} .$$

there is, essentially, th. possy. of an ∞ of ~~spaced~~ squares between = and □.

~~Tues~~, July 10, 1956 : day of talk on T.M. to Dartmouth group: Minsky, McCarthy, McCulloch, Shannon, attended – also partly Bill Schutz.

Criticisms:

1) They would like to do a hand simulation of this (Shannon in partic.)

2) McCarthy expressed worry about th. length of some of th. search processes that mite be involved.

3) Minsky suggested ad-hock soln. of th. str. for and seems quite happy to add all sorts of ad-hock mechanisms, if they seem very useful. I am afraid that

a) He is overly impressed by th. necessity of built-in mechanisms.

b) He isn't aware that ad-hock mechanisms are bad since in using ~~it~~ them, one misses one more chance to pick up the clue of a ~~generality~~, very general mechanism, that ~~one~~ may be th. difference betw. "creative" thot and not.

.30 α58.01

Th. problem about setting up "classes of classes of classes" etc. in T.M., can, I think, be solved by giving ~~them~~ detailed instructions, in English, then coding them for T.M.

A class may be defined by ① a set of instructions telling one if an object is in th. class or not — also, it may contain quick-trial rejection/or acceptance methods that usually work. ② listing of class members ③ How class was constructed from other classes or n tpsts and strs.

α58

T.M.

We also have objects (e.g. permutations) which operate on strs. to produce sets of strs.
If $S_1, S_2 \ldots S_n$ ~~means~~ is a set of strs.

then $G_i \equiv S_i \cdot N_1$ $[i = 1/n]$ is a set of sets.

I think that there are others useful sets of sets.

3) We probably can use hyer order objects like sets of sets of sets.

The concept of "Number": We can use Russel's definition: 2 ≡ th. set of all pairs of objects. We can have th. "betweeness" relation: e.g. <th. set of all triples> is "between" th. <set of all pairs> and <th. set of all quadruples>.

We must design T.M. so that this does turn out to be a "useful" concept, and that it is made likely that T.M. would "discover" it.

M. suggests that th. word "integer" mite be difficult to define. This is a set of sets, but it has infinitely many members, which is a difficulty. However, many other of T.M.'s sets mite be thot of as having ∞ members. E.G. ~~any~~ th. digram 01, may be thot of as including all situations α57

Mon July 9, 1956

T.M.

How to get concepts like "number".

E.G. Consider that T.M. [illegible] finds that

1□ , 1B□ , 1BB□ , 1BBB□ are all useful.

would he be able to extrapolate that 1BBBB□ was probably useful?

To start from th. beginning: ~~we have sets~~

1) we have sets of phenomena. These sets have th. property that they group phenomena in ways that are useful for prediction. I.e. so that th. occurance of one element of a set can be used as statistical data for th. occurance of other members of th. set. 2 members of th. same set are "close" to one another in ~~2) we hav~~ a "way" that is named by th. set name.

2) 2 sets are "close" if th. [illegible] empirical usefulness of one suggests that th. other is probably useful. "Closeness" suggests sets of sets. I.E. "closeness" suggests "neighborhoods", [illegible] A closeness relation on a set of pts. is partly defined by a set of points sets, such that all th. members of each point set are close together.

Anyway, in general, the concept of set of sets is useful.

Th. factorization concept also gives sets of sets. Say a ngmst., G, is generated by str. S_1 mult. by ntpst, N_1.

$$G_1 = S_1 \cdot N_1$$

If S_2 is close to S_1 then $G_2 \equiv S_2 N_1$ is close to G_1

α56.

Fri July 6, 1956

T.M.

Methodological Note: It appears that sub-goals (and sec. reconf) — see Minsk α 51.10.30ff are only imp. in T.M. problems involving a search. E.g. in a well defined problem of th. 1st kind — where one must invert some definite operator. There are many imp. T.M. problems that do not involve searching (This isn't absolutely certain). For this reason, it appears worth while to solve th. non-search problems *first*, since they are simpler. A search problem involves all the techniques of a non-search problem, plus the extra problem of devising sub-goals. I think that once the non-search problem is solved, the search problem will be easy to do, using the techniques of abs. construction that were devised on th. non-search problem.

Th. devising of abstractions sometimes involves searching. E.g. the inversion of certain xfmns. is *very* often useful.

For prelim. work, however, we may simply assume that we *can* carry thru th. search process succesfully — say be means of a very large fast computer

One also feels that if, in th. past, $\overset{0}{\square}$ has implied $\overset{0}{\boxed{0}}$, this fact should be made much of.

A very good reason why I would want $\overset{0}{\boxed{0}}$ to be of hy U: In R.W. language, it is the events that do occur, that get words assigned to them, not $\overset{0}{\boxed{1}}$, which is of zero frequency.

A temporary way to "solve" this problem: (temporary in th. sense of enabling me to continue with the review on Math. T.M). Th. "ngmst" $\overset{1}{\square}$ will have assoc. with it, a U, and a vector, whose components give th. probty. of various ~~completions of these~~ digits in $\square$. this ngmst $\overset{1}{\square}$ also has other prediction params. Th. "Rough and dirty" B.G. soln. that will be used at first, is that we take th: ngmst of hyest U and aprip (meaning? —⟨since probty is a vector⟩) or, more exactly, th. "Best" ngmst, and use its probty vector as th. soln. In th. case of several ngmsts all about of = goodness, average their vectors in some way — (or convolute them(?)) — Anyway, if these "Best" vectors differ much, give th. resultant a low relyability.

It is very probable that previous discn. of ~~what~~ how to make freq. counts in Math T.M. has looked into this point. X 858A has something to say about this, but not too clearly.

This approach of suggesting that one take th. "Best" ngmst and use its vector, isn't so bad. If several ngmsts should have their vectors combined to give th. final result, perhaps th. ngmsts themselves could be combined in an optimal way to yeald an even more optimal ngmst.

Th. trouble with th. $1\,\square$ type represantation, is that $1\,\boxed{\alpha}$, $0\,\boxed{\beta}$, $0B\,\boxed{B}$ could not be members of th. same set. This may not be imp. for very low level problems, but it is certainly imp. for complex problems.

Thurs July 5, 1956

T.M.

In writing a review of work on Math T.M., th. foll. prob. has come up:

We are trying to predict the $\boxed{?}$ square in

$$\begin{array}{l} =1\,1\,0\,1 \\ \quad 1\,1\,\boxed{?}\,1 \end{array}$$

We ∴ want the rel. probability of

$$\begin{array}{l} =1\,1\,0\,1 \\ \quad 1\,1\,\boxed{0}\,1 \end{array} \quad \text{and} \quad \begin{array}{l} =1\,1\,0\,1 \\ \quad 1\,1\,\boxed{1}\,1 \end{array}$$

There are 24 possible adjacent binary digrams containing $\boxed{}$ — assuming that the 3 possl. completions could be 0, 1, or space.

We would think that th. digrams of greatest U would be $\overset{0}{\boxed{0}}$ and $\overset{0}{\boxed{1}}$. However, if th. digram $\overset{0}{\boxed{1}}$ is used along with any other digram like $\boxed{0}\,1$, of non-zero frequency, prediction is as good, or almost as good. $\overset{\boxed{0}}{\text{null}}$ gives as good prediction as $\overset{0}{\boxed{0}}$. for n examples, the freq. of occurance of $\overset{0}{\boxed{1}}$ is zero; $\overset{0}{\boxed{0}}$ is $\frac{n}{4}$; $\overset{\boxed{0}}{\text{null}}$ is $\frac{n}{4}$ (in fact $\overset{\boxed{0}}{\text{null}}$ happends <u>if and only if</u> $\overset{0}{\boxed{0}}$)

For this reason, $\overset{0}{\boxed{1}}$, $\overset{1}{\boxed{0}}$, $\underset{1}{\boxed{0}}$ and $\underset{0}{\boxed{1}}$ get <u>hy U</u>: $\overset{0}{\boxed{0}}$ etc. get about th. same U as most other digrams.

It would <u>seem</u> intuitively, that $\overset{0}{\boxed{0}}$, etc. <u>ought</u> to get hy U, and that $1\,\boxed{1}$ etc. ought to get about <u>zero U</u>. — yet $1\boxed{1}$ gets as much **U** as $\overset{1}{\boxed{1}}$.

Also, th. soln. to B.G. that is to be applied, isn't at all clear. There is a kind of soln. on X 898.24, but it is still in too complex a form to understand what it mite mean (even approximately) in any specific cases.

Also, it is felt that if one has statistical info. on 2 mutually incompatible ngm types, like $1\boxed{0}$ and $1\boxed{1}$, one should make much of this info. At th. present time, it is not too clear as to how this should be done.

Tues July 3, 1956
T.M.

T. M.. This is ~~because we have~~ because it appears that we can go extremely far, without having to alter th. basic abs. methods very much — i.e. strs. and ntpsts. Certainly it seems that "+ with carry line" is possl., and *very* probably most hyer operations with little basic modification.

SN At th. present time, creation of new abstract entities by *inversion*, is being looked upon as a ~~super~~ not very special case of th. creation of a set by "multiplication" of e.g. strs and ntpsts. E.g. A gp. α is found to be of hy **U.** α is then found to be factorable into th. structure S, and the ntpst, μ, so $\alpha = S\mu$. If μ is of hy U, then **S** becomes of hy apri. U ~~a/o~~ of hy aprip.

Actually, there is a rather serious search process involved. One can, mathically, state that for any α of hy U, then for any ~~μ~~ μ of hy U, $\ni S\mu = \alpha$, the aprip of **S↑**. However, often, one will not find this S,μ pair, since the computer available, ~~will be~~ is very limited in capacity. The finding of such an S,μ pair will be a real *discovery*, and will not allways occure, even when such a pair exists. The amount of time that one wants to spend looking for such pairs, will be sharply limited, but in general, for any μ of hy U, many $S\mu$'s will be tried, to see if they yeald something *close* to a gp. of hy U.

In some cases, th. "division" of α by μ can be carried out to yeald **S**.

Sun July 1, 1956 Hanover, N.H.

T.M.

Some config. eval. methods will assign variances along with values. As i increases, effective variance decreases.

Actually, th. variance of an evaluation will depend upon how many moves into th. future one's opponent looks.

If one *has* these variances, one can know just how many moves to pursue each line of play. There is, however, th. Q. of whether at any time, it is better to stop and spend time evaluating a move, or to proceed with further analysis into th. future. One may ~~evolve~~ invent special quickly-applied evaluators, for preliminary determination of whether to use a hyer powered evaluation scheme, or simpley continue tracing into th. future

Is it possl. to make use of some of th. work done in deciding on th. previous move, to reduce th. search process for th. present move?

$\boxed{\text{SN}}$ Math T.M. starts on T.M. X729 with discn. of several kinds of probs. to work. X730 has list of some fairly good probs., ∋ if they were solved by T.M., we would feel that it was really learning things. Also, it seems not too unreasonable that after learning all that math, T.M. should be able to learn to understand Q's posed in a simple lang. — perhaps, eventually, English.

To understand English, however, it may be nec. to get T.M. to be able to predict analog events in R.W. — then translate them into English, and use th. analog events ("concepts") to extrapolate English — or to "understand" it.

A somewhat more detailed "learning sequence" for the initial stages is on X774. From X774 to X780 is a discn. of whether or not Math T.M. is of much use — i.e. is it likely to demonstrate "creativity" a/o understand English?

As a final remark: A criterion of whether Math T.M. is really *being* "creative". If, after a long while, T.M. has been producing what would normally be regarded as "creative" results, and has had no new ad-hock abstraction method inserted into his program for a very long time, then we will say that Math T.M. is really being creative.

At the present time, there seems to be reason to believe that we *can* expect creativity from

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Just what would an efficient search procedure be in these games? Would there be much difference ~~in~~ batw. chess or checkers?

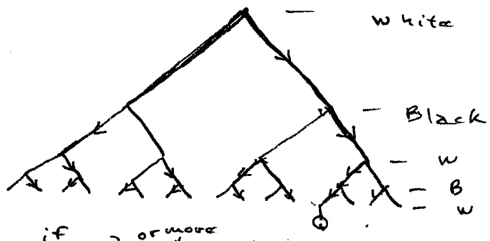
2 ~~samp~~ eval. methods can always be compared: Simply take a large no. of ~~past~~ configurations that are of reasonable ~~frequen~~ prob. and apply both methods. Then use a 3rd method (or one of th. 2) that has been "souped up" by, say, a 5 move exhaustive search, to decide which configurations are "really" the best. Compare th. orderings of th. 2 ~~comp~~ methods to be compared, with th. "true" ordering.

For ~~so~~ optimum searching, at each point in th. search, each move under evaluation will have a certain expected G and a variance about this G. Decisions to go ahead with a search line or drop it, can be then made on this basis. For example, consider game in which each player only has 2 possl. moves each turn. E.G. Bk. and white tokens. 1 dimensional board. Each player places token ~~on~~ on North or South end of pile. A player wins if he gets ~~some~~ some of his tokens to ~~form~~ occupy all th. points of coordinates $ni+a$ ~~[illegible]~~ $[i=1 \mid n]$

n, a = any integers, a may be <0, n must be >0 { n must be >2.

for $n=2$, this may be too easy. This game may be trivial.

To figure out lines of play, one works backwards.



First one ~~evaluates~~ compares all moves in th. last row, in pairs. One discards th. worst, then compares at next level, etc. Th. arrows show th. choices that were made.

Note: if 2 or more terminal pts. are equally good, we will have some arb. choices

~~Each position has a set~~

Say one can linearly order all configurations. Then one can easily make all choices. A config. has a set of values $a_1, a_2 \ldots a_n \ldots a_\infty$. a_i is th. optimum value obtained after an ~~plus~~ exhaustive search i moves into th. future. a_∞ is th. true value of th. move — usually ∞ is $<\infty$; or we may have a draw. Usually as $i \uparrow$, a_i will not be even approx. monotonic — except if a_i becomes very low or very hy — in which case an imp. man is won or lost, or th. game nears its end.

T.M.

and th. method that uses th. "carry" line.

~~The~~ Above method of "carry line" elim. may not be so good. It seems that in addition problems, one does th. carry's in one's head, and it may be expedient to have T.M. learn to do this.

Also, there are probably many processes in which ~~aum~~ aR'_b , ~~&~~ bR''_c cR'''_d $\supset$ aR''''_d

this suggests it may be o.k.

and it is only aR''''_d that one cares about. To put it another way, one may go from form "a" to ~~[illegible]~~ form "d" thru a b c d, so that abcd is of reasonable proby. — then one really only wants a d. This can be accomplished by a special operation on th. trio of pairs: $f((a,b),(b,c),(c,d)) \equiv (a,d)$. This is not as general as th. set of xfmns:

$(a,b) \rightarrow (c,d,e) \rightarrow (f,g,h)$ and it is only (f,h) that one wants. Well — th. operation $(f,g,h) \rightarrow (f,h)$ is certainly simple enuf, and is by <u>no</u> <u>means</u> a <u>new</u> xfmn or an <u>ad-hock</u> one.

SN Chess and Checker playing machines:

A fairly good checker player has been constructed by ? AP75 A. Samuels

{It plays out all sequences to 5 moves, then counts men and uses amt. of "centralness" for tie breaking.

~~Any~~ On evaluating a position:

Any 2 evaluation methods can be compared. Say method A takes t seconds to use, and B takes k t sec. (k>1) suppose that there are m alternative moves on th. average. Then playout all positions $\log_m k$ moves in advance and use method A. Compare win probability with B, when B is used immediately.

It may, indeed, be true that few eval. methods are as "good" as a very simple method such as

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T.M.

.01 α46.32 For example: I was worried about the learning of "addition without carry line". Intuitively, th. soln. is as follows:

$$\begin{array}{l} +1101 \\ n0101 \\ \hline 11110 \\ 10100 \leftarrow \text{"soln"} \end{array}$$

we can factor this in to th.

ntpst $(+1101,\ 0101,\ \overset{11110,}{/10100,})$ and th.

str $\boxed{\begin{array}{c}1\\2\\3\\ \hline 4\end{array}}$

$\boxed{\text{SN}}$ Tom has suggested, that to simplify explaination, write strs. as a vector, with ~~[illegible]~~ each vector component giving th. cart. coords of th. displacement of that component relative to th. first component.

e.g. $\boxed{1|2} \equiv (0,0),(1,0)$ $[x, y]$

$\boxed{\begin{array}{c}1\\ \hline 2\end{array}} \equiv (0,0),(0,-1)$

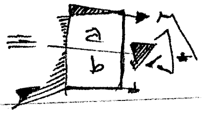
$\boxed{2|1} \equiv (1,0),(0,0) \equiv (0,0),(-1,0)$.

In th. last case, we illustrate th. fact that any constant 2 dim. vector can be added to all components of a str. and leave th. str. invariant. Th. "str." is ~~[illegible]~~ th. part that remains invariant under such an xfmn.

$\boxed{1|2} \times (a, b) \equiv \boxed{a\ \ b}$

$\boxed{2|1} \times (a, b) \equiv \boxed{b|a}$

$\boxed{\begin{array}{c}1\\ \hline 2\end{array}} \times (a, b) \equiv$



$\boxed{\text{SN}}$ There is still some trouble with th. i.p. ($\boxed{?}$) in th. intuitive approach that is being outlined above.

To get $\begin{array}{r} +1101 \\ 0101 \\ \hline 10100 \end{array}$ ~~on 0101 11101~~

we mult $(+1101,\ 0101,\ 11110,\ 10100)$ by

$\boxed{\begin{array}{c}1\\ \hline 2\\ \hline 4\end{array}}$

Similarly, we can get 0101 + 1101 = 10100 with a little extra trouble. In fact this may be better to learn than ___, since there is some ambig. later α48

$\alpha 46$

T.M. Friday June 22, 1956

choices toward hyast p_i.

The function x^r is th. "only" (probably only analytic) funct. that satisfies th. functional equ. $f(x) \cdot f(y) = f(xy)$. [r can be anything]

This means that if the p_i's are obtained by Monte carlo methods and for all p_i's, $p_i = p_{i1} \cdot p_{i2}$, then one can suitably ~~[illegible]~~ non-linearize ~~the~~ p_{i1} and p_{i2}. p_{i1} and p_{i2} may, in turn be obtain as random variables. Eventually, at some low level, one may obtain some random Monte Carlo variables ~~that~~ ~~[illegible]~~ whose probies one can modify by ~~[illegible]~~ $p \to p^r$, since the number of such low level variables is small — much smaller than th. no. of p_i's.

General Methodological note: In working, say, on Math T.M., keep operations much closer to intuitive processes than I have been doing. Th. definitions of strs. and utpsts, and their cart. products, ~~should be~~ are things that I feel that I understand intuitively, and so I should be able to do it more exactly.

$\alpha 47.01$

.32

.37

Some Induction Postulates : ~~B. Russel "Philosophy" — 1924~~ Most recent refrence: Russl: "Hum Knowl.— its scope and limits" p526 couldnt find it — AP75

1) post. of quasi-permanance (in time) [but also in space]

2) post. of separate causual lines. (a thing usually isn't caused by everything

3) " " spacial temporal continuity (no action at a dist.)

similar to 1), but in both time and space.

4) " " common causual origin of similar strs. grouped about a center. [a center in time or space] [this may also involve post. of "parsimony of explaination".

5) post. of analogy

It would be imp. to see if these posts. are "suff" — i.e. can one develope all rules of induction that one uses, from them. $\alpha 47$