IRE talk

2) Examples of simple induction probs. in which there is ~~only~~ one and only one correct answer. simple Arith.

a) Show slide #1. — with = probs.

12) b) Introduce concept of pugm. and "consistency".

c) Show slide #2 -(⊕ and ⊗) - give quick explaination.

4) introd pugmsts

5) Basic Idea: formation of ~~Good~~ Ngmsts. — That 1st law of thermo (as was mentioned) is expressable as an ugmst.

6) Start with ~~B~~ basic set of abss. — these are ugmsts and other objects — strs, utps, utpsts.

Try th. ugmsts on probs gn. to machine: Good ones retained rest discarded.

10) 5) so much for general theory: now just what has been done?

(a) A ~~program~~ program written for a machine able to learn simp. arith. from series of examples.

This machine uses only a few abs. types, and methods of creating new abss.

Show, perhaps, slide on Boolean probs.

In almost suff detail for ......

20

b) Some work done on mechanics of more complex machines to work more difft. probs.

i) e.g. $+_0^w$ in some detail. Uses concept of pugmst, and a few other sets of abss. Slide #3.

ii) Machine to ~~rec~~ recog. Grammar (Chom II and III)

Would probably ~~...~~ devise and use Chom's abss. for ch. II

" " ~~[illegible]~~ " abss dift. from Choms in ch. III.

~~iii~~ This would be stoch. machine. — would also give "gram rite" but meaningless or false sentences, low proby. Will not disting. betw. rite grammar and rite meaning. Also stoch. machine ~~[illegible]~~ indip. of small errors in input.

iii) Sets of sets avail, but no probs. ~~[illegible]~~ worked on in which they are nec.

(6) What are main probs:

a) Are abs., and methods of gen. them suff. for all probs. of int." (They can't be "complete", but are they fairly good?)

b) Th. search prob.! is most impt / dift. present prob. exhaustive search OK. in Semp. Mach. — but not in more complex — how to solve Th. search prob. (be sure they understand what search prob. is)

Th. search prob. is quite ~ to th. prob. of ~~constructing~~ new abs. from old.

Idea is: Once one has a / trial search method, one can evaluate its effectiveness and speed. Start with a method that ~~works~~

loosly speaking: start with one or more search methods that are known to be good (~~[illegible]~~ — builtin) Combine ~~these~~ and xfm these in various ways, to produce new trial search methods.

Eval. these.

Adding th. newly found bunch of good search methods to th. old stack, combine and xfm them for new trial search methods, etc.

Thus this iterative proccedure is quite ~ to th. abs. gen. method, ~~and th. xfms and comb. rules, the~~ and is closely related to it.

a) Movie: Margret O'Brien, B. Karloff, ~~[illegible]~~

categories: M. O'Brien : 60 % of time.

B. Karloff : 80% of time.

Both — zero sample.

First names of main actors M and B : 60% of time (≡ 40% for all movies)

b) Physical laws: e.g. 1st law of thermo.

category of all known situations in which relevant data taken and law held

vs. " " " " " " " " " " ~~[illegible]~~

Q: Isn't th. search problem extremely dift.? I.e. you have essentially reduced th. ind. inf. prob. to a prob. that is just about =ly ~~worse~~ dift.!

~~A: Th. search prob. is as dift. as th. gen. prob. of proving math theorems (No this will cause confusion, because th. Math prob. is formally unsolvable!)~~

A: This prob. is dift. However, it can be solved if one knows how to generate ~~new sea~~ promising new search methods from old ~~one~~ search methods that have been known to be successful. In ~~an~~ ~~an~~ analysing th. abs. gen. prob., I believe that I have also made much progress in this search method gen. problem.

V ③ ⓒ ngmsts.

i ntpst → ngmst.

ii $\delta \equiv \frac{\alpha}{\beta, \gamma}$ means $\beta \cdot \delta \cdot \gamma \subset \alpha$.

Slide #9

iii $\alpha \cdot \beta$

iv $\alpha \cap \beta$

ⓓ Examples of how ~~"passive"~~ "active to passive" xfmn is done and how "and" combination is done.

slide #10

i Passive: $NP_1 \cdot Aux \cdot Verb \cdot NP_2 \rightarrow NP_2 \cdot Aux \cdot been \cdot Verb \cdot by \cdot NP_1$

$(4,2,5,3,6,1) \times [V_4 \cap (\underset{1}{NP_1} \hat{x} \underset{2}{Aux} \hat{x} \underset{3}{Verb} \hat{x} \underset{4}{NP_2}) \hat{x} \underset{5}{been} \hat{x} \underset{6}{by}] \rightarrow$

$\underset{4}{NP_2}\ \underset{2}{Aux}\ \underset{5}{been}\ \underset{3}{Verb}\ \underset{6}{by}\ \underset{1}{NP_1}$

slide #11.

ii "and" xfmn: $W \alpha_i Z,\ W \alpha_i Z \rightarrow W \alpha_i \text{ and } \alpha_i Z$.

$(1,2,4,5,3) \times [V_3 \cap \underset{1}{\Omega} \hat{x} \underset{2}{\alpha_i} \hat{x} \underset{3}{\Omega}) \hat{x} \underset{4}{and} \hat{x} \underset{5}{\alpha_i}] \rightarrow \underset{1}{W}\ \underset{2}{\alpha_i}\ \underset{4}{and}\ \underset{5}{\alpha_i}\ \underset{3}{Z}$

VI MT ① PSLMTTM

ⓐ Def. of a "corpus" ~~sets~~ of a Lang.

≡ set of all as's.

ⓑ Gn. L_1 and L_2 — define corpus of L_3.

ⓒ L_3 may be a PSL.

ⓔ Example of its initial ngm. and permissible substitutions:

1.

slide #12

Σ: S, S' F: $S \rightarrow$ A B / B' A'

A → C D / C' D'

S / S' → A B / B' A' → C D B / B' C' D' ← phrase in L_1 ← phrase in L_2

ⓓ If L_3 is a PSL it is solvable by ngmsts.

slide #13

i. Some ngms: a, b & or ac; b

ii 4 possl. combination rules for a, b and c, d —

ac, bd; ac, db; ca, bd; ca, db.

V My own approach to the Grammar Recog. problem.

① Soln. of PSL and FSL by ngmsts.

ⓐ Def. of ngm. example: [abbb. , or a, or bc,

ⓑ ~~Ngmst~~ Def. of ngmst. examples:

[a, abc, ab, ~~z~~m, b could be an ngmst.

set of all Noun phrases, etc., set of all ~~m~~ male sing. noun. phrases,

sets of all verb phrases, etc.

ⓒ Creation by ~~[illegible]~~ definition of complete context.

e.g. The boy ~~x~~ x the toy. : All ngms (=words or phrases) that x could legally be.

~~that could~~ b

or Y saw the toy : similarly for th. ngmst generated by Y.

ⓓ creation by concat. of ~~[illegible]~~ prev. defined ngmsts.

slide #5 e.g. $\alpha \cdot \beta$.

$\alpha \equiv$ [the, a]

$\beta \equiv$ [Boy, toy, ~~[illegible]~~]

$\alpha \cdot \beta$ = [the Boy, the toy, a boy, a toy.]

ⓔ Discovery of identity of various ngmsts, defined in different ways.

e.g. x_i Boy saw the toy. & ~~[illegible]~~ $[x_i] \equiv \alpha$

the Y_j saw the toy $[Y_j] \equiv \beta$.

slide #6

Z_k saw the toy $[Z_k] \equiv \gamma$

then $\gamma \subset \alpha \cdot \beta$. is a "discovered" relationship.

ⓓ ~~[illegible]~~ Possl. to generate all membs. of all ngmsts from knowledge of i. comb. rules betw. ngmsts. → which ngmsts are included in which others

ii

iii a few initial membs. of certain ngmsts.

↑#3

↓#4

② PSL with context dependent subs. probly cannot be done with 2 above xfmns only. int. ∩ may be suff. — or others may be nec.

③ XL : several new abs. and xfmn types needed.

ⓐ Ntpsts i all ngmsts are 1tpsts.

ii (α, β, γ ..) by cart. product of ngmsts a/o ntpsts.

Slide #7

iii V_K [Th. set of all k-tuples ∋ when concat, an as results]

iv ∩ ~~[illegible]~~

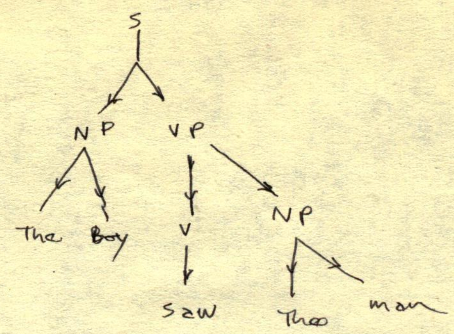
slide #8 ⓑ strs. (1, 2, 1, 1) × (a, b, c) = (a, b, a, a)

(2, 1, 3) × (a, b, b) = (b, a, b) } asside on

B

Namor Paper : Outline 2

Slide # 2 (cont)



ⓒ Can generate infinitely long sentences: -

eg. Slide # 3 Σ: a

F: $a \to bab$.

a , bab , bbabb , bbbabbb etc.

| aBc $\to$ aCDc

~~Gramm~~ This lang. cannot be gen. by ~~a~~ FSG.

ⓓ Context dependent substitutions (see slide # 3)

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③ XL ⓐ Starts with "kernel" sentences ~~that~~ (usually generated by PSL).

ⓑ Perform xfmns on ~~a~~ kernel sentences to get new s's

ⓒ " " " new ~~s~~s's to get " " .

ⓓ Examples: Slide #4.

1 { NP_1 - Aux - Verb - NP_2 $\to$ ~~The~~ NP_2 - Aux - been - Verb - by - NP_1.

John has eaten the pie $\to$ The pie has been eaten by John

2 { ~~a~~ Z - X - W ; Z - Y - W $\to$ Z - X and Y - W

John came to school ~~today~~ ; John ate breakfast today $\to$

John ate breakfast and came to school today.

3:02

④ Pattern Conception (N. Chomsky and ~~...~~ G.A. Miller).

Def. of Problem: To find Grammar rules for lang. - ~~a~~ 2 forms

ⓐ i) large set of s's - to find rules.

ii) ~~...~~ Allowed to ask ~~...~~ "teacher" if a certain s is an s.

iii) Usually mixture of ~~a~~ i and ii used.

3:04

ⓑ ~~...~~ Soln. of FSL gn.

i) Not obviously generalizable to PSL or XL.

A

2:32 The Mech. of Ling. Learning. Namur Paper : Outline₂

I What is ind. Inf. ?

1. General Rule from many isolated cases.
2. Same as problem of Prediction [e.g. Weather]
3. Pattern completion.

II My previous approach ~~and direction of work~~.

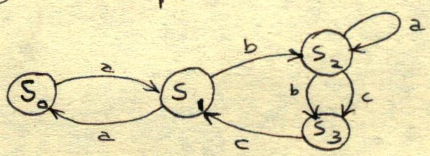
1. Use of categories for prediction e.g. Cloudy day → rain.
2. Good categories → good predictions.
3. Prob. of devising ~~cat~~ good categories. ← start with primordial abs — build up cats and new abss. progressively.
   - (a) Assigning U's to cats..
   - (b) Hyer order abss — how U's assigned to them.
   - (c) Continuing process of producing New abs. from Old, and Ueval ← Ū and Ū ~~together~~ give final U.
4. Problem of Useful abs, and abs xfmns
5. Problem of Ueval.

III Previous applic. to arith.

241 1. Reasonable success with ~~tex~~ simple arith learning, using very simple abss, and xfmns.

242 IV Chomsky's work.

1. FSL : (a) Generated by Finite State Machine.
   (b) Example : slide #1



permissable Sequences ! → a a, states → $s_0\ s_1\ s_0$ → $s_0 \overset{a}{\,} s_1 \overset{b}{\,} s_2 \overset{a}{\,} s_2 \overset{a}{\,} s_2 \overset{c}{\,} s_3 \overset{c}{\,} s_1 \overset{a}{\,} s_0$

(c) Chom. showed that English is not a FSL.

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2. PSL (a) Consists of phrases that have been concat. into sent. — th. phrases in turn may be concat. of other phrases, etc.
   (b) can be gen. by substitution.

Example : slide #2 : Σ: S

F: S → NP · VP

NP → The · N

N → Man, Toy, Boy, Airplane

VP → V · NP

V → saw, sees, is, was ....

S

NP · VP

The · N · VP

The N · V · NP

The N · V · The N

The Boy saw The N

The Boy saw The Man

Notes for talk to MT Group at MIT Tues Aug 19, 1958
Chomsky out of town, however.

List of topics of interest.
Use this as outline of SF paper.

1) How to solve FSL's

~~Equiv classes~~

(a) Most general way, using $< 2^{N^2}$ classes $\leq (2^N)^N \gg$ ~~[illegible]~~ $N^N > N!$

(b) Using only classes of terminal sequs. and 1 digit mult table. $2 \times 2^N = 2^{N+1}$ classes needed

$2^{N+1} << N! \approx N^N$. If there are, at most, 3 possl. state endings for each seq. then th. max. no. of equiv. classes is $\approx N^3$.

2) Ngmst method for PSL's.

(a) Ngm may be word or seq. of words

(b) ~~Ab~~ Ideally Ngmsts corresp. to "developement" of an element x in PSL. $F: X_i \to Y_i$.

(c) Give example of how "multiplication" rules are discovered.

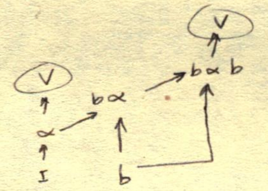
or if $F: a \to bc$, $b \to de$, $c \to af$. Then $ngmst_a = ngmst_b \cdot ngmst_c$.

e.g. a aba bbabb

Σ: a

F: $a \to bab$ | $\equiv \alpha$ then $b \alpha b = \alpha$.

or



(d) F. abc → ~~[illegible]~~ aABc not done in detail —

(e) Th. Search prob. — probably the "index tabs" or ~~∄~~ ∧ may be used. See 847.10 – .22 for how ∧ can do it. (also ∧ is necy).

3) MT for PSL's.

(a) $L_1, L_2 \to L_3$ How L_3's ~~costs~~ "corpus" consists of sentence pairs.

(b) ~~How Ngmst types~~
How L_3 is a PSL : What its Σ is. {see 843.30}
What its F is.

(c) ~~How to get trial~~ what ~~∄~~ ngmsts look like

~~[illegible]~~ ① A_i, B_i with 4 possl. comb rules for pairs of ngms (rather than 2)

~~or ② A_i, B_i~~

(d) How ngmsts are searched for: 844.37. ff

4) XL's.

(a) Th. now operating ~~m~~ and abss. needed: 886 – 888

(b) Some examples: 889 – 890

NP - AUX - Verb - NP_2 ⇒
John has eaten the pie
NP_2 Aux be + en - Verb - by NP_1
~~John has eaten the pie.~~
The pie has been eaten by John.

5) XL MTTM.

(a) Use of abs. pairs. i.e. a ngm may be paired with an xfmn.

6) On How getting TM to produce "true" sentences is a special kind of "Gram. discov." prob. — That this skill will be needed for medium level MT — i.e. simple ambiguity resolutions

Note change of order

4) (c) Ngmsts

(1) V

(2) all known words are ngmsts.

(3) $\frac{\beta}{\alpha,}$ or $\frac{\beta}{,\alpha}$ [$\frac{V}{\alpha,}$ and $\frac{V}{,\alpha}$ are commonest]

(4) $\alpha \cdot \beta$ (concat).

(5) $\alpha \cap \beta$ (int.)

(6) Str × Ntpst.

(d) Ntpst

(1) every ngmst.

(2) $(\alpha, \beta, \gamma \ldots)$ is an ~~ngms~~ ntpst ($\equiv \check{x}$).

(3) $\cap$ of various ntpsts of = n : e.g. $(\alpha, \beta) \cap (\gamma, \delta)$.

(4) "dividing" V by $nstr_0$. — gives 1 ntpst for each value of n. — Show how it is used to get $\frac{V}{\alpha,}$, $\frac{V}{,\alpha}$.

(b) Strs (1) permutation a/o ~~m~~ repetition a/o ommission.

(b) Solved for some PSL pairs — Modifies Rearrange E

i. Rearranges sentence order, completely

ii. Interp. of word in certain kinds of context.

iii General incomplete state of work.

(2) "Machine language" approach:

(a) Simplified English → machine orders

(b) Machine orders → simplified Eng.

(c) Advantages — machine orders are operational meaning

— is ∴ ~~idea~~ similar to human learning of 2 aspects of lang.

i. How speech sound tells about world.

ii " talking may effect world.

Makes ~~santa~~ ~~ie~~ L → L xltn. possl.

VII Gen. Conclusions:

~~(a)~~ (a) Goal was finding abss. and xfmns useful in many fields

(b) Present abss and xfmns seem ~~a~~ useful in both arith, and linguistic Learning.

Actually Given Feb 10, 60
at . Cal. Tech.

Feb 10, 60 (00) why ask? — i.e. dissatisfaction with ~~types~~ — Other trivial models 2

Reordering: — What is prob.? — How all learning can be simulated by ii machine. 3

I actually gave some of this: 25 min total inc. qs.

0)

1) Parsimony (exact statement)

2) Simplest eq. [Don't give rigorous defn. of lang. yet]

3) Σ method.

4) Gives same results for ∞ sample.

[redacted] " some new results, quantitative. (curve fitting)

" " " quant. discn. of ~~vague~~ intuitive ideas on hypoth. formation, etc.

5) Machine defn. of dern / input sequs. are "lang" — Corpus defines Grammar.

6) Indip. of proby on nature of Machine

7) "World view." (~~—~~ complete adequacy of model).

8) Discussn. of ~~[illegible]~~ (a) Rαβabk

(b) Curve fitting.

(c) Gives same results for contin. of dip. data.

9) Physical realization (a) By random and trials

↑ diflt. (b) In hill-climbing. {How different from Friedberg's simulation.

??

10) Mention Operators

11) Actually Creative

2) Exp

7) ~~[illegible]~~ Equivalent non-min. coding ~~method~~

a) Example. R ~~[illegible]~~ αβ abk.

b) curve fitting.

~~[illegible]~~ c) Operator analysis

~~8) World View~~

8) Physical realization

a) ~~£~~ direct — random trials of terminal bits.

b) Hill climbing on ops.