NATURAL-LANGUAGE GENERATION

Language generation is the production of linguistic utterances guided by communicative intentions. There are two main forms, speaking and writing; the producing agencies can be people or computers. In practice, however, the term 'language generation' refers to the composition of printed text by computers. The length and complexity of the texts may vary from elliptical answers to questions (e.g. in a natural language dialog system), to multi-paragraph reports (e.g. in an explanation facility which forms part of an expert system). There is also growing interest in the automatic generation of spoken language. Theoretical and practical work in this area aims at the integrated design of generators capable of converting communicative intentions into high-quality, prosodically well-formed speech (as opposed to bipartite designs consisting of a printed-text generator which feeds into a text-to-speech converter).

In the late 1980s, language generation technology is beginning to approach practical applicability. Although most existing generators are laboratory prototypes, some are already being applied in information and dialog systems which do not demand a high level of linguistic and stylistic sophistication, or in environments where only a subset of a full-fledged generator's components is operative. Examples of the latter are (semi-)automatic translation which can do without a representation of communicative intentions, and text critiquing which may involve rephrasing rather than generating a text. However, natural language generators are not always developed for practical purposes. They may also serve purely scientific functions, e.g. grammar testing (checking the consistency and completeness of a set of grammar rules), or psycholinguistic modeling (building a computational model of human language production).

The oldest artificial natural language generators—more properly termed 'sentence generators'—date from the early 1970s. Their target language was English; AUGMENTED] TRANSITION] N[ETWORK]S served as the central linguistic formalism. *[See* Natural Language Processing, *article on* Grammar Formalisms.] Input to these generators consisted of shallow meaning representations for isolated sentences. In the 1980s, emphasis shifted to discourse and dialog planning. ATNs fell into disuse, giving way to a range of linguistic models and formalisms. These trends were heralded by Davey's 1979 discourse production program based on Systemic Grammar. The list of target languages is growing slowly but steadily; in addition to English, it includes Dutch, German, Swedish, French, and Japanese.

The global architecture of the language generation process can be explained with reference to the following outline (based on Levelt 1989 and using his terminology wherever applicable). It features the principal components that would be needed in a full-fledged language generator. (In existing generators only a subset is realized.) The list reflects a decomposition of the language generation process which is emerging from both computational and psycholinguistic work.

Processing components of natural-language generators

A. Conceptualizer
- A.1. Macroplanner (communicative intentions => illocutionary acts)
  - Discourse plans (rhetorical structure)
  - Pragmatic goals (social, emotional, etc.; rhetorical effects)
- A.2. Microplanner (illocutionary acts => preverbal messages)
  - Reference (referential expressions, surface speech acts)
  - Information-processing constraints (topic, focus, prominence)

B. Formulator
- B.1. Grammatical Encoder (preverbal messages => surface structures)
  - Lexicalization (lemma selection)
  - Syntactic tree formation (functional and positional trees)
- B.2. Phonological Encoder (surface structures => phonetic plans)
  - Lexicalization (selection of phonological wordforms)
  - Prosodic planning (intonation contour, metrical structure)

The CONCEPTUALIZER is responsible for planning the meaning content and rhetorical organization of a text. The FORMULATOR prepares the grammatical and phonetic shape of individual sentences. The conceptualizer delivers a text in the form of a sequence of preverbal messages which is fed into the formulator. A preverbal message specifies all information that the formulator needs in order to convert the message into a sentential or subsentential (elliptical) expression. Not shown in this outline is an OUTPUT component which realizes utterances phonetically or orthographically.

Each main component consists of two cooperating subcomponents, the first one having a more global span of control than the second. The MACROPLANNER is capable of structuring the contents of possibly extensive discourse units. The MICROPLANNER deals with a few adjacent preverbal messages at a time. Within the formulator, global control is exercised by the GRAMMATICAL ENCODER while constructing full sentences. The PHONOLOGICAL ENCODER needs simultaneous access to no more than a few successive syntactic constituents. There is only a one-way flow of information (preverbal messages) from conceptualizer to formulator. An indirect feedback loop from formulator to conceptualizer passes through the monitor (see below).

The macroplanner receives as input communicative intentions generated by an expert system, a question-answering system or some other application program. A communicative intention specifies a desired mental state in the addressee (e.g. knowledge, belief, or intention). In response, the macroplanner starts composing a PLAN which will bring about the goal state. The resulting plan is a sequence of one or more illocutionary acts—speech acts such as 'inform somebody of something', 'request somebody to do something', etc. *[See* Pragmatics, Implicature, and Presupposition.] This planning activity requires powerful reasoning methods tuned to the logical structure of the content domain; it must be sensitive to the knowledge that is already available to the addressee and his/her emotional state. Appelt 1985 has developed a generator which meets many of these demands.

Within the conceptualizer, illocutionary acts are represented as expressions over a 'private' vocabulary of terms which denote actions, objects, states of affairs, events, etc. To make these 'referents' recognizable for the addressee, the microplanner forms conceptual (descriptive, referential) expressions. For example, 'person25', a referent, is replaced by the conceptual expression underlying noun phrases such as *the vice president* or *your boss,* depending on the addressee. In addition, the microplanner attempts to facilitate the addressee's interpretive task in various ways:

(a) It assigns prominence to descriptions of newly introduced referents, thus influencing pitch accent placement during later phonological encoding.
(b) It marks some description as topic. This usually causes it to be grammatically encoded as the subject of the sentence. The addressee takes the topic's referent as the best memory location to store the information expressed in the remainder of the sentence.
(c) The microplanner maintains a list of referents which are in focus, i.e., currently being attended to. It will refer to focused referents by anaphorical expressions (e.g. *he/him* as subsequent reference to person25). Or it can signal to the addressee that a new referent is brought into focus, e.g. by using indefinite reference as in *He had an accident.*

DISCOURSE STRUCTURE PLANNERS have been designed by McKeown 1985 and by Mann & Thompson 1987. Grosz & Sidner 1986 worked out a conjoined treatment of discourse structure and focusing. Hovy 1987 and Jameson 1987 have studied the process of planning for certain emotional and social effects.

The conceptual structures delivered by the conceptualizer are fed into the formulator. These preverbal messages trigger abstract (pie-phonological) lexical items of the target language. These items are called LEMMAS. On the basis of their syntactic properties, the grammatical encoder attaches them as terminal nodes to tree-like structures specifying constituent hierarchy, grammatical functions, and left-to-right position. These surface structures serve as input to the phonological encoder, which fleshes them out with information determining the global sound shape of the final utterance. This activity includes replacing lemmas by phonologically specified word forms, and computing prosodic patterns.

The most popular linguistic formalisms used in the formulator component of language generators are Systemic Grammar and Unification Grammar. Some researchers, notably McDonald 1983 and Danlos 1985, have designed new grammar formalisms which are specifically tuned to the demands on the formulator (see also Kempen & Hoenkamp 1987).

A final remark about the generator's control structure. Although, viewed globally, the four subcomponents operate in series, there is ample opportunity for parallel processing. For instance, the grammatical encoder need not wait for the microplanner to deliver a complete preverbal message. Grammatical encoding can begin upon receipt of a partial message. This will result in a syntactic fragment to be completed as soon as further parts of the preverbal message have been elaborated; this is termed INCREMENTAL PRODUCTION. Thus the microplanner and the grammatical encoder may be working simultaneously on the same sentence, although on different parts. A comparable situation holds for other processing components. However, the occurrence of incomplete inputs has a drawback: it increases the probability for the generator 'to talk itself into a corner'. This circumstance is one of the reasons for including a MONITOR in the generator's design. Its task is to diagnose troubles incurred by any component, and to reactivate earlier components with modified inputs.

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