Automatic question generation for Swedish: The current state

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Abstract

The research area of question generation (QG), in its current form, has a relatively brief history within NLP. A description of the current question generation implementation for Swedish text built on schema parsing is here presented and exemplified. Underlying the current approach is the view of 'all textual information as answers to questions.' This paper discusses strategies for enhanced functionality for arbitrary Swedish text through extended question generation. It also brings up some theoretical issues regarding the nature of the task, and concerns practical considerations in an area such as Intelligent CALL (*ICALL*) where this type of application has been considered for English.

1 Introduction

The field of question generation can be said to have old roots in AI research, but a young community involved in research on QG, particularly regarding the English language, has now appeared and brought a reoccurring international workshop series into being.[1]

A definition of the QG task in general is to exhaustively produce all questions that a text can be said to provide the answers to. (This definition is taken from proceedings edited by Rus and Graesser, 2009.) Whether or not such a definite *exhaustive* set for any text is possible to determine is of course debatable.

QG for arbitrary text is a type of NLP application that puts special demands on contributing basic NLP techniques. QG for Swedish with the current approach (see figure 2) relies on a parsing format where the identification of spans of functional constituents, such as adverbials, must be exact and include post-modifiers. For Swedish text, there exist a few parser implementations with such suitable capabilities for free text. QG for arbitrary Swedish text has, to the best of the knowledge of the author, only been undertaken using schema parsing (Wilhelmsson, 2010),[2] which currently only gives a parse of the main clause level, see example 1. (QG for Swedish was introduced as one of the suitable applications of schema parsing independently of ongoing research on English, then unknown to the author, *ibid,* chap. 5). In the recent QG research period, a number of plausible areas of application for QG have been identified. Swedish QG has to this point been seen especially in the light of information extraction *(IE)*, see figure 1. In this approach, the text database of Swedish *Wikipedia* was used frequently as a text source, and the role of QG has been as a generic usability resource aimed at enhancing quick access of specific portions of information. Why should then explicit generation of questions be used in a

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[1] See http://questiongeneration.org/

[2] Tasks similar to or equivalent of QG for Swedish has however been discussed by researchers considering the inductive dependency parser *MaltParser* (Nivre 2006).

general information extraction setting? The idea about QG in natural language query interfaces has been that a UI allowing arbitrary natural language questions as input too often results in only 'best string matches'; there is no guarantee that a freely formulated question actually is answered at all in the current text database. Fully functional QG, on the other hand, ideally only allows a user to choose among the explicit questions produced, answered by the text by grammatical definition (see figure 1). In the GUI of the QG program has an auto-completing dropdown-menu allowing only generated question to be posed, see figure 1. However, the QG program for Swedish described here may be used for other purposes.

The pedagogic situation, such as tutorial dialog, is often mentioned in the literature regarding QG. The international research describes uses of QG in ICALL applications such as automatic generation of exercises (eg. Lefevre Jean-Daubias, and Guin, 2009, Wyse and Piwek, 2009). QG in an ICALL setting has a potential use in automatically created tests of reading comprehension. In an ICALL setting, new subtasks such as selecting a useful subset of all questions generated appear.
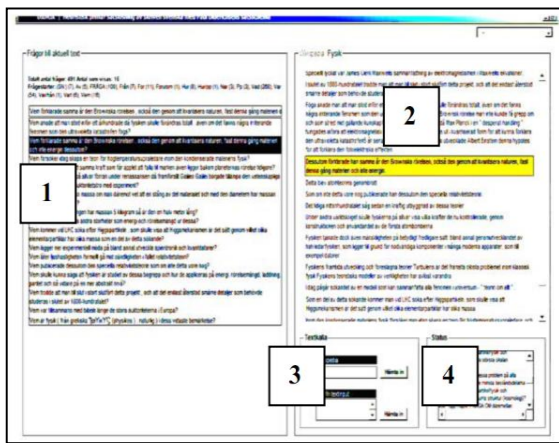
Figure 1: The GUI of the QG program for more general information extraction (taken from Wilhelmsson 2011)
1) Autocompleting input form for choice of question
2) The text source in which the suggested questions will mark and scroll to the corresponding section with answers
3) Forms for choice of Wikipedia article or text input
4) Status box displaying various information during a run.

1.1 Outline

This paper begins by describing experiences with development of Swedish QG so far; it also discusses possible improvements for potential applicability to areas such as Intelligent CALL.

Section 2 starts by describing the existing implementation, where questions concerning explicit full main clause functional constituents are treated. It also brings up additional question types stemming from partial and multiple functional constituents.

Section 3 deals with questions that could be produced using minor deduction techniques, notably pronoun resolution.

Section 4 brings up how a more advanced QG system could use 'shallow reasoning', logical conclusions and possibly exploit semantic lexica to draw conclusions resembling more human-like reasoning.

Section 5 brings up reformulation of information as a strategy, e.g. in ICALL. While not resulting in true change of content, altering syntax and vocabulary of facts can be motivated for testing the reading comprehension of a student.

Section 6 deals with a theoretical aspect of QG and explains why certain texts can appear self-contradictory from this QG viewpoint.

Section 7 discusses weaknesses in the current QG implementation. Achieving high correctness in QG can be regarded as a form of the common situation in NLP where both precision and recall rates must be raised simultaneously.

2 Generation of questions answered by explicitly stated information

Question generation regarding explicit information from functional grammatical constituents in Swedish declarative sentences has been the initial focus for Swedish QG. Generation of questions concerning (i.e., *that are answered by*) the unbounded constituents (subjects, objects/predicatives and adverbials) can in general be carried out as in Wilhelmsson (2011) by a three-step procedure, as in figure 2. Identifying full spans of the constituents considered is a prerequisite. The method has declarative main clauses, or coordinated finite VPs (that inherit subjects from a previous structure) as input.

1. Place the currently fronted constituent in its canonical position, thus creating a yes/no-question (V1 question).
2. Front each unbounded functional constituent of the main clause level. Fronting of the currently available subjects (formal and logical), objects/predicatives and adverbials, thus creates grammatical variations of the same propositions.
3. Substitute each of the adverbial and the nominal constituents with corresponding interrogative phrases, eg. *Wh*-words. This is not always possible or useful for all constituents.

	Canonical positions					
Fundament field	Primary finite verb	Nominal (subject)	Adverbial	Non-finite verb	Nominal (Object/predicative)	Adverbial
Fronted const.	v	n	a	V	N	A
	Kompilerar	*vi*			*koden*	*idag?*
Lit.:	*Compile*	*we*			*the code*	*today?*
När	*kompilerar*	*vi*			*koden?*	[-]
When	*compile*	*we*			*the code?*	[-]
	Har	*de*	*ändå*	*Undersökt*	*DNA*	*i fynd?*
Lit.:	*Have*	*they*	*still*	*Examined*	*DNA*	*in findings?*
Vad	*har*	*de*	*ändå*	*Undersökt*	[-]	*i fynd?*
What	*have*	*they*	*still*	*Examined*	[-]	*in findings?*

	Functional type	**Length/structure and type of grammatical constituent**
	Verbal v/V	Bounded. Reflexive pronouns, verb particles etc. belong to the same group.
	Nominal n/N	Unbounded. n) subject/formal subject. N) Objects/predicatives and logical subjects.
	Adverbial a/A	Unbounded. a) adverbials (often sentence adverbials). A) Adverbials

Figure 2. The procedure of fronting the unbounded main clause constituents and substitution with corresponding question segments – e.g. a single *wh*-word (with literal English translations). The sign *[-]* marks *traces* (gaps). Only one adverbial (*idag/today*) and an object (*DNA*) are shown here. However, it also applies (if suitable) to the other candidates *vi/we → who, koden/the code → what, de/they → who, (ändå/still → ε)* and *i fynd/in findings → where*.

The Nordic sentence schema, introduced for Danish by Diderichsen (1946) in figure 2, can be used to describe the general QG process regarding full syntactic constituents dealt with here, theoretically working also for other Germanic languages, except for English, which is not a *V2* language. (In this paper dealing with Swedish, examples will sometimes be given in English when analogous to Swedish.)

The result of the schema parser used here comes in an XML format. The output of the schema parser (example 1) is the input of the QG procedure above (figure 2).

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<subjekt>Johan</subjekt>
<pfv>skulle</pfv>
<adverbial>alltid</adverbial>
<piv>försöka</piv>
<piv>fundera</piv>
<adverbial>på vad pappa hade sagt att
man skulle göra</adverbial>
<tom>.</tom>
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Example 1. Tag names: pfv – primary finite verb, piv – primary non-finite verb, tom – 'empty'. So-called prepositional objects are seen as adverbials. 'Primary' here means 'on main clause level'.

The text parsed in example 1 (*Johan skulle alltid försöka fundera på vad pappa hade sagt att man skulle göra./Johan would always try to think about what dad had said that one should do*) originally comes from Stockholm Umeå Corpus 2.0 (Ejerhed, Källgren and Brodda, 2006), unit: kk70-010.

The approach for Swedish QG described here bears some resemblance to an approach for English: *[...] the derived declarative sentence is turned into a question by executing a set of well-defined syntactic transformations (wh-movement, subject-auxiliary inversion, etc.). The system explicitly encodes well-studied linguistic constraints on wh-movement such as noun phrase island constraints [...]. The transformation rules were implemented by automatically parsing the input into phrase structure trees with the Stanford Parser [...] and using hand-written rules in the Tregex and Tsurgeon tree searching and tree manipulation languages.* (Heilmann & Smith, 2009)

2.1 A brief authentic example

An account of actual question generation for Swedish from an early test with a short text is shown in example 3. The excerpt comes from the article *Brödrost* (*Toaster*) from Swedish *Wikipedia*), five sentences. Each main clause is processed and coordinated main clause level finite VPs are turned into main clauses by inheriting the most recent main clause subject in the text sentence. The example shows questions derived from *explicit full main clause constituents* (subjects, objects/predicatives, adverbials).

1) Brödrost är en elektrisk apparat som värmer upp bröd.
   [A] toaster is an electrical device that heats up bread.
2) Oftast används vitt bröd till detta.
   Usually, white bread is used for this.
3) Brödet får en lite mörkare yta som dessutom blir lite spröd efter att brödet är rostat.
   The bread gets a somewhat darker surface that furthermore becomes a bit crisp after being toasted.

4) En brödrost har elektriska värmeelement bestående av glödande trådar som värmer upp brödet.
   A toaster has electrical heat elements consisting of glowing wires that heat the bread.
5) Den elektriska effekten hos brödrostar är oftast 500-1000 watt.
   The electrical power is most often 500–1000 W.

Eleven unique generated 'candidate questions' was the actual result. As shown, all of these are not grammatically correct.

a) Vad är den elektriska effekten hos brödrostar oftast?
   What is the electrical effect for toasters mostly?
b) Vad är en elektrisk apparat som värmer upp bröd?
   What is an electrical device that heats up bread?
c) ?Vad är brödrost?
   ?What is toaster?[lit., sic]
d) Vad används till detta oftast?
   What is used for this most often?
e) Vad får en lite mörkare yta som dessutom blir lite spröd efter att brödet är rostat?
   What gets a somewhat darker surface that furthermore becomes a bit brittle after being toasted?
f) Vad får brödet?
   What does the bread get?
g) Vad har elektriska värmeelement bestående av glödande trådar som värmer upp brödet?
   What has electrical heat elements consisting of glowing wires that heat the bread.
h) Vad är oftast 500 - 1000 watt?
   What is most often 500–1000 W.
i) ?Vart används vitt bröd oftast?
   ?Whereto is white bread used most often?
j) ?Vilka har en brödrost bestående av glödande trådar som värmer upp brödet?
   ?Which do a toaster have, that consists of glowing threads that heat up the bread?
k) *Vilka har en brödrost elektriska värmeelement?
   **Which has a toaster electrical elements?*

Example 3. A sample text and actual generated questions.

Adverbial structure	Example	Adv./Nom. (as a group)	Possibilities for mapping
AdvP	*Bra/good*	Adv.	Usually pure mapping or none
PartP	*Förvånande/ surprising*	Adv./Nom.	Usually pure vague mapping *(hur/how)* or none
AdjP (or derivations)	*Lyckligt/happily*	Nom./Adv.	Usually pure mapping or none
V1 conditional	*Funkar det/ (lit.: Works it)*	Adv.	(No obvious *wh*-question mapping)
Sub clause	*Som det verkar/ as it seems*	Nom./Adv.	Usually pure mapping or none
NP	*En dag/one day*	Nom./Adv.	Usually pure mapping or none
As-phrase	*Som målvakt/ As a goalkeeper*	Adv.	Usually pure mapping or none
PP	*På bordet/ on the table*	Adv.	Complex situation; many exceptions

Table 1. The various adverbial structures considered with short examples. An in-dept account is given in Wilhelmsson (2012).

Table 1 describes the starting point for finding *wh* correspondences for adverbials from a technical perspective. Adverbials form a large, diverse group. Many types, however, have pure mappings, and question word correspondences can be determined by the phrasal head or similar.

Whereas Swedish adverbials have a large number of potential question counterparts, the situation for nominal constituents (subjects, objects/predicatives) appears to be much simpler. Full nominal constituents mostly correspond *to vad (what), vem (who/whom)* or *vilket/vilken/vilka (which* SING-UTR, SING-NEU, PLU). The choice of the correct counterpart is dependant of the semantics of the head words. Animate references will correspond to *who,* whereas *what* is the default. '*Which*' (Swe: *vilket/vilken/vilka*) is primarily used for full constituents when the set of referents is presumed to be of a fixed size. When a nominal constituent is a named entity (e.g. *Volvo*), there appears to be a need for correct semantic classification, as Volvo will correspond better to *what company* than *what* or *who*.

Only generating these various types of questions stemming from explicit full main clause constituents already means a large set of questions. A rough estimate was around four questions per sentence in some text types with normal settings.

The type of questions answered which have explicit information as answers exemplified above, i.e. those corresponding to full main clause constituents, is the sole question type that has been investigated carefully and implemented to this point. Particularly, the multi-facetted *wh*-question counterparts of Swedish adverbials have been the focus of a recent research project. [3] Swedish adverbials considered come in roughly eight different structural forms, using the phrase categories naturally discerned when using the de facto standard tagset for Swedish from Stockholm Umeå Corpus 2.0 (Ejerhed et al., 2006), see table 1.

Figure 3. A web GUI of the implementation of identification of head words and heads of prepositional complements *(on the old roof of the house.)*for adverbials. In this case på ('on') and taket ('the roof') are identified and used to decide the *wh* mapping – *var/where*.[4] The rank numbers below determine these words and come from rank-based chunking (see e.g. Wilhelmsson, 2010).

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[3] A working paper report in Swedish is available at: http://gup.ub.gu.se/publication/160440-adverbialkarakteristik-for-praktisk-informationsextraktion-i-svensk-text-projektrapport Wilhelmsson (2012).

[4] An online implementation of this is available, currently at: www.ling.gu.se/~kw/applications/adverbialkarakteristik/index.htm It may later be available from: spraakbanken.gu.se

In many cases the head word alone decides appropriate *wh* correspondence for adverbials. In the common PP adverbials, particularly for the common *in/i, to/till* etc. the head of the prepositional complement must also be examined, see figure 3. More precisely, the base form of the head of the prepositional complement marked in yellow in figure 3 is preferable. *SALDO* (Borin, Forsberg and Lönngren, 2008) was used for this purpose.

2.2 Other potential questions answered by explicitly stated information

Other explicitly stated information in natural text that could be made to yield new questions includes the following.

2.2.1 Questions answered by full clauses: *Yes/No* questions

Questions answered by full propositions*: It rains today* can easily be used to produce the corresponding *yes/no*-question *(Does it rain?).* In Swedish this means a *V1*-question. As described in Wilhelmsson (2011), this type of question may be less useful – at least in an IE setting: the answers to yes/no questions just confirm the fact (The mere existence of the question 'Does it rain' means that the information 'It rains' is present in the text).

Some sentence adverbials and the like such as *kanske/maybe* may also be seen as answers to *yes/no*-questions. In general, they do not correspond to any particular *wh* question word, like other adverbials.

2.2.2 Questions answered by parts of full constituents and subordinate constituents

Questions regarding smaller information portions than full main clause functional constituents, like modifiers, clearly constitute a large amount of all realistic questions.[5] *The oldest student closed the door → Which student closed the door?* If the schema parser is enhanced to yield a similar detail

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[5] In a sense, questions regarding smaller parts of information than full constituents is partly present in the current version of the Swedish QG implementation: A pied piping question, *He gave it to me → To whom did he give it,* is a question regarding the prepositional object *to me* but focusses on a part of it (i.e. its complement, *me*). This becomes clearer in the version with a fronted complement and stranded preposition: *Whom did he give it to?*

of analysis for subordinate clause levels, this clearly will lead to a much larger set of information portions and corresponding questions, by allowing additional questions regarding full and partial subordinate functional constituents: *I think that they will buy the car → What do you think that they will buy [-]?*A rough estimate is that half of the grammatical sentences in published Swedish text (SUC 2.0 was examined) include at least one subordinate clause, i.e. sub-clauses (including relative clauses) with finite verb forms.

2.2.3 Questions answered by clause segments spanning more than one full functional constituent

The above description points to several ways of extending the number of questions produced for a text. In actual discourse, however, many question types such as *varför/why* are answered not by one or a few functional constituents (like the *eftersom/because* sub-clause for *why*) but by a series of sentences with an enormous potential syntactic variation. The aim here of course is to investigate QG systematically, and to do so by going from an expression to the corresponding question, rather than the other way around.

Questions of the type *Vad gjorde de/What did they (What did they do)* deal with full VPs including objects etc. These questions appear to be possible to generate, although not all VPs correspond to *do*. See section 6 below.

3 Generation of questions from explicit information with a minor degree of deduction

The previous section has shown that the explicit information can yield a large number of questions. Still, these correspond only partly to the full set of questions that a text provides answers to. Another type of information requiring some deduction comes from treating certain subordinate clauses like main clauses. E.g. from the main clause; *He knew that they were wrong*, the proposition *they were wrong* might be deduced (provided sub-clause analysis). Depending on the nature of the type of sub-clause and verb, such conclusions may or may not be drawn.

Other types of less obvious questions that can be generated include those stemming from anaphoric references, which clearly is a large class of

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(particularly nominal) information in text. This may turn out to be particularly useful in ICALL applications. In the QG implementation aimed at information extraction the GUI 'answered' a question by showing the sentence from where the question was extracted, together with its context. The answer is often an anaphoric expression such as *he*, and this has not been problematic since the user herself solves the referent. On the other hand, an application built for practical ICALL purposes might require resolved anaphoric references, so that answers can be given explicitly.

For Swedish, at least two different main strategies for anaphora resolution can be distinguished. The first comes from a heuristic, very economical rule set proposed and tested by Fraurud (1988). The second type is more influenced by English algorithms, especially of one by Mitkov (1998). In the second approach, pronoun resolution takes many surface aspects into account, weighted for optimal performance. Swedish elaborations have incorporated mixes of the two. Recent attempts for Swedish include hybrid methodology (Nilsson, 2010) combing data-driven and rule-based techniques. Other carefully adapted approaches for pronoun resolution have been presented, eg. by Hassel (2000) and by Algotsson (2007).

4   Logically deduced questions

The kind of information content that humans perceive from text widely exceeds the obvious manifestations covered this far.

All persons born in the US are American citizens.
[…] Barack Obama was born in the US.
→ Barack Obama is an American citizen.

Example 4. An example of a deduction with *universal generalization* in English text.

Deduced questions through rules of logic such as *universal generalization* and other techniques, involving e.g. lexica of semantic information such as *Swedish WordNet* (Viberg, Lindmark and Lindvall, 2002) or *Swedish FrameNet* (Borin et al, 2010) is a class of questions whose size becomes extremely hard to estimate. That will make the concept of 'all questions that are answered by a text', used in a definition of QG vague. In fact, the exact set of questions that each text ought to

'produce' remains unknown, as discussed above. A direct consequence is that it will not be possible to assess relative coverage of a question set generated, see Wilhelmsson (2011).

5   Reformulations of questions

In the information extraction setting mentioned, the idea of QG was to let a user only ask questions which were generated, ensuring that there would be answers in the text. An obvious difficulty was that the user had to *find* the question – more precisely: a formulation of a question in the usually very large set of questions produced. A slightly counter-intuitive method for helping the user finding a question was discussed in Wilhelmsson (2010, 2011) – extending the 'set of questions' even more by adding reformulations. The early tests furthermore showed that substituting words by Swedish near-synonyms from *Folkets synonymordlista* (Kann and Rosell, 2005) and Swedish WordNet (Viberg, Lindmark and Lindvall, 2002) to add alternative question formulations, without word-sense disambiguation, produced many erroneous questions. In an ICALL setting, it may however be a well-founded idea to use the slightly altered correct formulation of a question to test the reading comprehension and vocabulary of a student.

In Wilhelmsson (2010), different *syntactic* changes to Swedish text preserving meaning was also discussed. Whether any of these are relevant to pedagogic situations is not clear, although most of these should be accomplishable in QG, and could similarly produce a not too obvious variant of the information in a teaching situation.

6   Identical questions and the time aspect

Consider a text article about a particular person. Many sentences may involve this one person as a subject, perhaps in an anaphoric form. The result for QG will be something that has already been noted in current implementations: there will often be several identical questions produced. Those will have different origins in the text and therefore different answers. Especially the VP type of question sketched above (*What did he do?*) might be generated repeatedly in that context. Clearly, a human teacher or similar would ideally choose not to pose that type of question at all.

Another aspect of this 'question ambiguity' is that many text types (e.g. the '*story*' genre) do not capture a fixed point in time with a world in a static state, but rather a time span involving new events and changes to the states of objects in the world, throughout the text. Consequently, such a text may, by different text sections, indicate both that 'the weather was sunny *and* stormy', that 'two persons have never met *and* that they met' etc. A text written with this ongoing flow of events will generally have this effect on QG.

7   Weaknesses in the current QG implementation

The QG implementation for Swedish was developed independently of the English approach. QG for Swedish was originally an idea about putting schema parsing to optimal use. From the beginning, an idea was to produce *as many questions as possible* – whether useful or not, this 'total' approach was thought to bring forward some interesting aspects.

As mentioned, this strategy turned out to be similar to one of the approaches used for English; *overgenerate and rank* (Heilmann and Smith, 2009). Producing all questions or near-questions will generally lead to many irrelevant or less useful questions. In that approach, the act of total question generation by syntactic means is fairly termed overgeneration. The second step; ranking or selecting what may be useful questions is then the real challenge. It seems likely that linguistic theory of information structure can be helpful here. A *rhematic* portion of text (according to theory of information structure) is likely to produce a more relevant question, in some rather general sense. Identifying those portions automatically would clearly be an interesting task.

The situation described here, that there is currently much 'overgeneration', together with the previously stated fact; that many of the plausible and useful questions are not among the generated ones, gives the picture that current implementations suffer from two 'opposite' weaknesses: too many useless questions generated (weak 'precision') and too few of the truly relevant are generated (weak 'recall').

Acknowledgments

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