Generating Questions and Multiple-Choice Answers using Semantic Analysis of Texts

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Contributions

- This is the first work to automatically generate questions from **multiple sentences**, involving specific **inference steps** such as coreference resolution and paraphrase detection.
- We present another approach which generates questions based on patterns extracted from relationships between events and entities.
- Our system also generates phrase-level distractors to challenge comprehension by using event-event relation annotations.

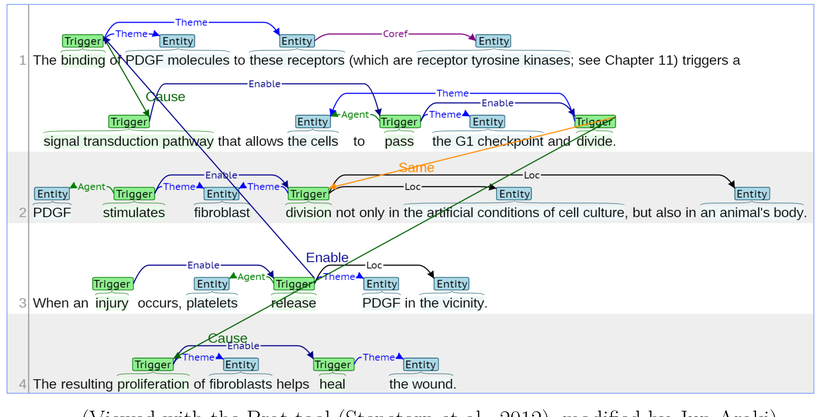
Introduction

- Goal: Automatic **question generation** (QG) for language learners.
- Our research can be useful to the task of creating exam questions and answers since automatic QG makes the task more efficient.
- **Higher-level questions** have more educational benefits for reading comprehension, as compared to simple factoid questions, e.g., (Anderson and Biddle, 1975; Andre 1979; Hamaker 1986).

Research Problems

- Existing QG systems generate questions from a single sentence, relying heavily on syntax and emphasizing grammaticality.
- The majority of questions generated from single sentences tend to be too specific and low-level, ending up essentially assessing the learners' ability to compare sentences.

ProcessBank corpus (Berant et al., 2014)
- 200 paragraphs from a biology textbook, with questions by biologists.
- We utilize human annotations of entities, events and relations.

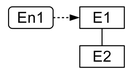
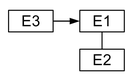
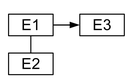
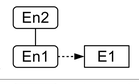
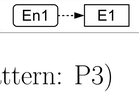


(Viewed with the Brat tool (Stenetorp et al., 2012), modified by Jun Araki)

Question Generation

Question Generation System 1 (QG1)

- Generate questions from multiple sentences using three semantic relations: event coreference, entity coreference, and paraphrases.
- Find answers using templates, and then construct questions.

Semantic relation	Question patterns	Answer	Question templates
Event coreference	P1. 	En1	T1. What [*verbal trigger* + *subsequent arguments*]?
	P2. 	E3	T2. What causes [*nominal trigger* + *subsequent arguments*]? T3. What makes it happen to [*verbal trigger* + *subsequent arguments*]? T4. What makes it happen that [*event clause*]?
	P3. 	E3	T5. What is a result of [*nominal trigger* + *subsequent arguments*]? T6. What happens when [*event clause*]?
Entity coreference	P4. 	En2	T1. What [*verbal event trigger* + *subsequent arguments*]?
Paraphrase	P5. 	En1	

Examples (Pattern: P3)
- Question: "What is a result of the fibroblast division not only in the artificial conditions of cell culture, but also in an animal's body?"
- Answer: "Proliferation of fibroblasts"

Question Generation System 2 (QG2)

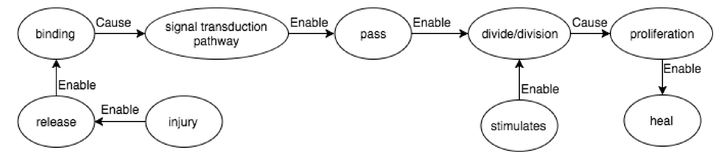
1. Extract generic patterns based on the relations between events and entities from a set of passages.
2. Apply the patterns to unseen passages and generate questions.

Question pattern	Question template
Entity *Result* Trigger	What event should occur before the *Trigger* of *Entity*?
Trigger_1 *Super* Trigger_2	What would happen without *Trigger_1* in *Trigger_2*?
Entity *Theme* Trigger	What would happen without the *Trigger* of *Entity*?
Entity *Location* Trigger	Where was *Trigger* in *Entity*?
Trigger_1 *Cause* Trigger_2	What is caused by *Trigger_1*?

- *Enable* relations tend to produce questions that have answers
- *Theme* relations tend to produce questions that may or may not have answers due to their ambiguity

Examples
- Question: "What event enables division?", Answer: "PDGF."
- Question: "What happens because of PDFG release?", (No answer)

Distractor Generation



Examples (against the example question by QG1)
- Distractor 1: "binding of PDGF molecules to receptor tyrosine kinases"
- Distractor 2: "PDGF stimulates fibroblast"
- Distractor 3: "platelets release PDGF"

Results and Future Work

Evaluation metrics
- Grammatical correctness: 1 (best): no grammatical errors, 2: 1 or 2 grammatical errors, and 3 (worst): 3 or more grammatical errors.
- Answer existence: 1 (yes) and 2 (no)
- Answer correctness: 1 (correct), 2 (partially correct), and 3 (incorrect)
- Inference steps: the number of semantic relations (event or event coreferences, paraphrases, or negations) humans need to understand
- Distractor quality: 1 (worst): confusing due to the overlaps with the correct answer, 2: easily identified, and 3 (best): viable.

System	Grammatical correctness			Answer existence			Inference steps		
	Ann 1	Ann 2	Total	Ann 1	Ann 2	Total	Ann 1	Ann 2	Total
QG1	1.52	1.48	1.50	1.17	1.26	1.21	0.80	0.71	**0.76**
QG2	2.13	2.07	2.10	1.58	1.75	1.67	0.31	0.20	0.27
MH	1.42	1.25	**1.34**	1.20	1.14	**1.17**	0.13	0.19	0.16

Question generation

System	Ann 1	Ann 2	Total
QG1	1.35	1.57	1.46
MH	1.08	1.13	1.11

(a) **Answer correctness**

System	Ann 1	Ann 2	Total
QG1	1.98	1.90	1.94
MH	1.93	1.88	1.91

(b) **Distractor quality**

Observations
- QG1 often fails to earn inference steps because the answer could exist in the same sentence as the question event with implicit relations.
- Distractors are often labeled as 2 ("easily eliminated") because they come from events closely preceding or following the question event.

Future work
- Explore more domain-adaptable question generation strategies.
- Develop an end-to-end system which takes raw text as input.
- Devise more intelligent ways of generating distractors.
- A real user test with non-native English readers.
- Automatically carry out one or more of our evaluation processes.

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