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研究課題名（和文）大規模の逆強化学習ための文脈データを収集するシステムの開発

研究課題名（英文）Development of a System for Collecting Context Data for Large-Scale Inverse Reinforcement Learning

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研究成果の概要（和文）：本研究は、機械学習に用いるデータを、現在一般的に用いられているコーパスにおける単なる単語の統計ではなく、人間の教師に相当するものとして作成することを目的としたものである。現在の知識グラフは事象の因果関係を推論するのにはあまり役に立たないため、事象を自動的に補完する手法を提案し、危険検出のタスクで文脈の小さな変化が結果をどのように変更するかを検証した。が、自動的なアプローチは不自然な補完に悩まされ、日本語の評価セットが存在しなかった。そこで、文脈変化の影響を認識するための21,592文と、ストーリー理解実験のための8,800の5文のストーリーという2つのデータセットを作成した。

研究成果の学術的意義や社会的意義
本研究の成果のアルゴリズムは、言語モデルの出力を知識ベースとコーパステキストを用いることによって部分的に制御することができることを示した。このアプローチは現在でも広く利用されておらず、制御されない深層学習が危険な判断をする原因になることがあり、社会が人工知能の研究を信用しない原因の一つでもある。本研究で作成したデータセットは、危険検知における文脈変化の影響に関するものとしては世界初で，大量なストーリーのDBとして日本語で初めて作成されたものである。両方のデータセットの公開は、人工知能が日常生活での行動が安全かどうかを検証するための新しいタスクを切り開く可能性がある。

研究成果の概要（英文）：This project aimed at creating data to be used in machine learning as an equivalent of human supervisor but in a deeper manner than plain statistics of words in corpora usually used today. Common sense knowledge is most often not explicitly expressed and semantic graphs as ConceptNet were proposed to enrich context processing. However, such graphs are not too helpful for inferring causal chains of events. To fill this gap I proposed algorithms for automatic augmentation of events and to examine how small changes of context change results of sentiment recognition task in context of potential danger detection. Although some results were promising, the automatic approach suffered from unnatural completions and there was a problem with evaluation as similar data did not exist for Japanese language. Therefore I created two datasets: a) 21,592 sentences for recognizing influence of contextual changes and b) 8,800 five sentence stories for story understanding experiments.

研究分野：人工知能

キーワード：知識獲得　因果関係　コモンセンス　文脈処理　ストーリー処理

１．研究開始当初の背景

My research interests are centered around three topics related to understanding – common sense processing, emotions, and ethical judgement for which two first topics play a crucial role. Teaching machines how people usually behave, what is the role of emotions and what behavior can be treated as immoral or dangerous would require an unimaginable effort and would be very costly, if possible at all. For this reason, researchers try to come up with methods allowing machines to learn automatically, but the mainstream of research in machine learning does not concentrate on retrieving high quality samples, especially when it comes to stories needed for a deeper context understanding. Back in early 2017, easy access to the large multilingual textual data was not as easy as it became three years later with an advent of large language models. I collected various corpora in different languages to compare how the retrieved data differ among cultures, but now in 2022 it can be done with prompting multilingual language models. But these models, although improving natural language processing tasks, have enlarged the problem of machine learning's transparency, showing that my proposed approach for thorough data collection and augmentation might bring solutions to these problems.

２．研究の目的

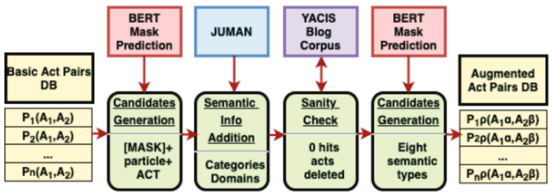
As mentioned in the previous section, my topic is to invent methods for providing machines data which could to some extent replace human teachers ("supervisors" in the supervised machine learning) by combining their knowledge to assure decision making without violating common sense. Natural language is just a code for communicating changes in the world that are not obvious for the most of observers, therefore it is not an easy task for a machine to extrapolate knowledge from such abbreviated representations of the world. For that reason, I am interested in retrieving descriptions of similar context, adding common details, reasoning about missing information and building datasets which can provide AI systems with a broader spectrum of contextual knowledge to avoid pitfalls of inadequate decision making. With this grant I planned to extend my previous work on utilizing findings from human science (McDougall's instincts, Kohlberg's stages of moral development and Nakamura's categorization of emotions) to other languages to see which parts of common sense or moral judgement is common among cultures and which parts are different) and build a dataset which would allow more flexible semantic processing as the current knowledge graphs are insufficient when the context changes are small. However, during the development process I realized that there are no Japanese datasets which could be used for testing algorithms for language understanding in this language and therefore concentrated on developing in the second stage of the research. Another sets of sub-goals was to experiment with various data and languages and analyze what kind of contextual knowledge is missing from the current data and what kind of problems such shortages can cause.

３．研究の方法

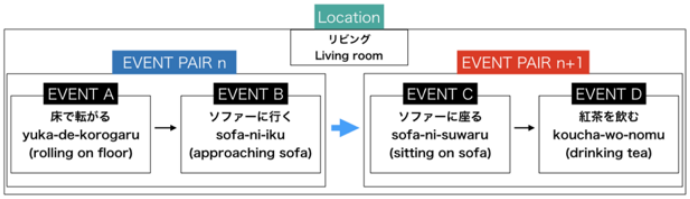
The realization of the grant's goal has been divided into stages. In the first stage I have utilized lexicons and multilingual corpora to see if there are visible differences between cultures when it comes to emotional reactions to human acts. A method for generating event chains using relevance filtering and for augmenting implicit knowledge as places as an example was created. Temporal events were created and their implicit relationship by relevance using a distributed representation of words was calculated. Likewise, relevant places were also added. Experiments were performed to show the temporal and semantic naturalness of the knowledge completion process needed to enrich machine learning. To see how the context influences machine learning, deep learning methods were used for Chinese (attention-based bi-directional long short-term memory recurrent neural network) and English (chained shallow neural networks) languages. For Japanese, standard classification methods (SVM, Naïve Bayes, random forest, etc.) were used for recognizing figurative speech. Linguistic phenomena like metaphors distinctly show the gaps between natural and machine understanding but because there is no word-level figurative language data for the Japanese language, it is difficult to draw clear conclusion and analyze the errors. I have realized that

there is no data which could allow testing context processing in Japanese language, so the final years I concentrated on data creation. I planned to use brain-storming-type data creation for various languages, but due to the COVID-19 outburst, I decided to switch to crowdsourcing limited to Japan and Japanese data. Differently from datasets developed for English, there are no Japanese equivalents that could be used for story processing (understanding, extension, and generation). To automatically generate longer causal chains, I experimented with completing implicit knowledge using relevance calculation of distributed word representations (see an example below).

In the next step I utilized BERT language model masking to fill semantic gaps. To control the generation, I introduced filtering method using JUMAN categories and web corpus. The figure below shows the algorithm.



Because there was no credible evaluation set for Japanese, to manually create it and divided the creation process into few steps. First, I have asked crowdworkers to fill gaps in simple sentences to have two distinct connotations – sound safe or dangerous. I chose this polarity because I wanted to create a dataset which is not as broad as common sense-related English data, but a set that is task oriented (providing a test set for robot helpers in an everyday environment) while requiring the whole spectrum of background knowledge. In the next step I asked another group of crowdworkers to evaluate the data regarding the level of danger. In the final step I asked crowdworkers to create short stories about dangerous and safe sentences developed in previous stages.



４．研究成果

After collecting data in other languages than Japanese, I first performed experiments with two additional languages (Chinese and English) to see how automatic consequence polarization can be helpful for obtaining basic knowledge about what undermines the basics of ethics - human feelings. Although no sophisticated language processing was used, both systems showed over 65% agreement with human judges. However, it did not come close to the results for Japanese – 85% of agreement. I have repeated similar experiments with sentiment for various languages by using zero-shot approach, but the classic lexicon-based approach was more precise. On the other hand, traditional word-matching methods suffer from low recall and are not able to deal with richer contexts as input.

In the second stage I continued observing how context influences various NLP tasks and found out that also multimodal factors (emoticons) play an important role for enriching context and providing additional information to help to estimate affect beyond positivity and negativity (Chinese). Another finding was that computer can learn a motivation degree of an advice depending on the context of the request for this advice (English), however the output was heavily dependent on the data used for learning. As mentioned in the previous section, I implemented few methods for automatic knowledge acquisition. The table below shows evaluation of semantic relation naturalness evaluation between event pairs which were generated in the act chain augmentation (5 is most natural).

Models\part	AB	AC	AD	BC	BD	CD	Chain
Word2vec	3.6	3.4	3.4	2.7	2.86	4.2	3.0
NumberBatch	2.73	3.57	3.13	3.33	2.7	2.83	2.57

The method I introduced for context completion by using BERT, JUMAN and web corpus yielded interesting results in regard of ethical contextual changes, but they also revealed problems with automatically generated data. The table below shows examples of relatively high agreement between human evaluators (H) and the system (S) - the higher score the less ethical the hitting act is evaluated. As shown in Actor and Place categories, BERT-based act generation has shown some tendencies characteristic to the Web as the knowledge source (wrestlers, dungeons, etc.).

Actor	Place	Mean	Patient	Reas.	H	S
child	ring	hand	child		7	7
wrestler	ring	hand	child		10	9
	ring		person		7	6
	street		person		8	6
	dungeon				3	6
	station				8	10
	ring				6	7
child	ring	hand	child		7	7
wrestler	ring	hand	child		10	9
	ring		person		7	6
	street		person		8	6
	hall	spell	character		4	4
	dungeon	spell	character		3	3
	hall	spell	character	attack	3	3
player	hall	spell	character	game	2	3

These results also revealed the problem of blanks which were difficult to be filled in and to acquire continuous causal data I decided to switch to crowdsourcing to obtain fuller chains as described in the previous section. In result, a story set consisting of 8,800 stories in Japanese language was created. To examine how machine learning can predict danger level of the sentences created in the process, error rates were measured, and BERT yielded best results as shown in the table below.

	LSTM		BiLSTM		BERT
	one-hot	Word2vec	one-hot	Word2vec	
MAE	1.050	1.174	1.041	1.085	**0.749**
RMSE	1.519	1.507	1.485	1.472	**1.082**

The stories require more thorough experiments which have not yet been performed for Japanese and the set is planned to be made public later this year together with a publication describing the results of baselines.

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２．論文標題 Stepwise Noise Elimination for Better Motivational and Advisory Texts Classification	５．発行年 2020年
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掲載論文のDOI（デジタルオブジェクト識別子） 10.20965/jaciii.2020.p0156	査読の有無 有
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	氏名 （ローマ字氏名） （研究者番号）	所属研究機関・部局・職 （機関番号）	備考

７．科研費を使用して開催した国際研究集会

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８．本研究に関連して実施した国際共同研究の実施状況

共同研究相手国	相手方研究機関