Cross-lingual Linking of Automatically Constructed Frames and FrameNet

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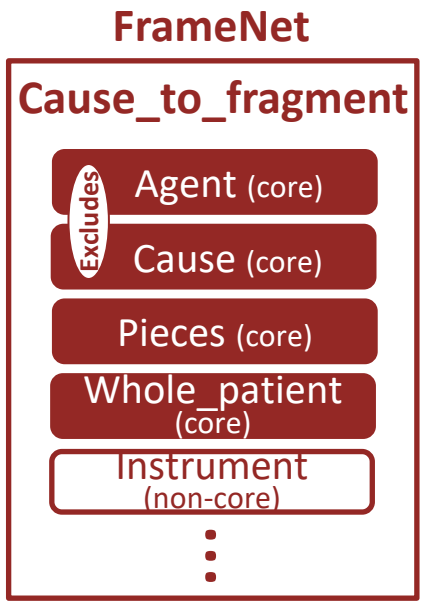
1. Introduction

➢ Semantic frame

- A conceptual structure describing an event, relation, or object along with its participants
  - Several resources, such as FrameNet (Baker+'98), VerbNet (Kipper+'00), and PropBank (Palmer+'05), have been manually elaborated
  - Various systems have been proposed for automatic construction of frame knowledge from raw corpora (Korhonen+'06, Kawahara+'14)

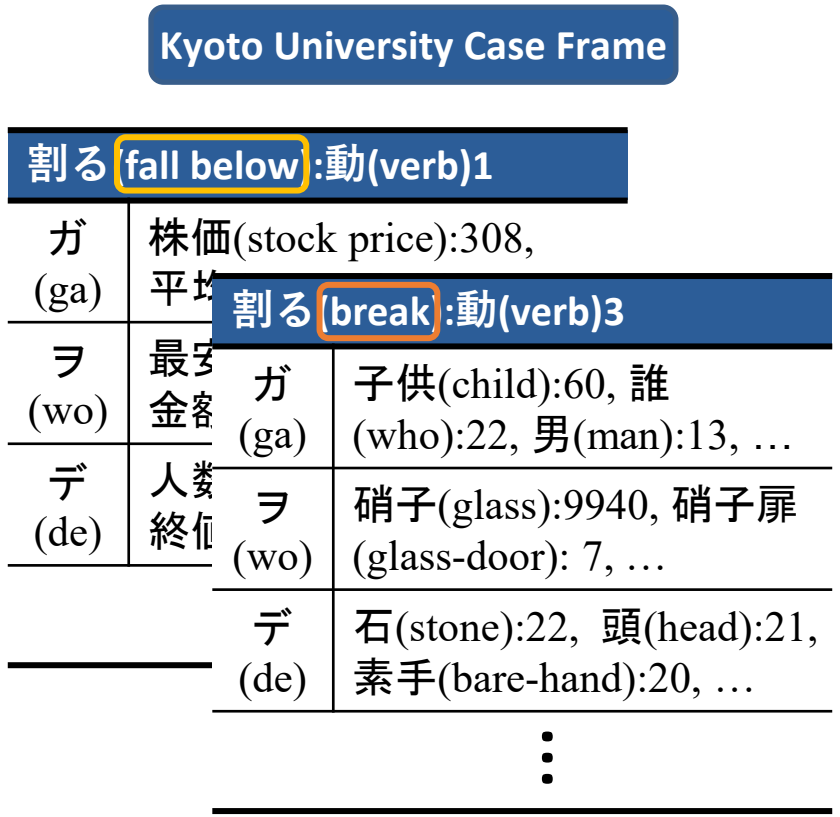
➢ FrameNet

- A representative frame resource
  - Providing rich semantic representations
  - Including 200K+ frame-annotated sentences
  - Being extended to roughly a dozen languages



➢ Kyoto University Case Frame (KCF)

- Example-based Japanese semantic frames (Kawahara+'06)
  - Constructed by clustering examples of predicates and their arguments according to semantic similarity
  - Examples are collected from a large corpus
- Frames are constructed for each meaning of each predicate
  - Japanese verb '割る' has several meanings such as 'fall below' and 'break')
  - In KCF, 'case' does not refer 'deep case'
  - Each frame describes the surface cases e.g., **ガ** (ga, nominative), **ヲ** (wo, accusative)

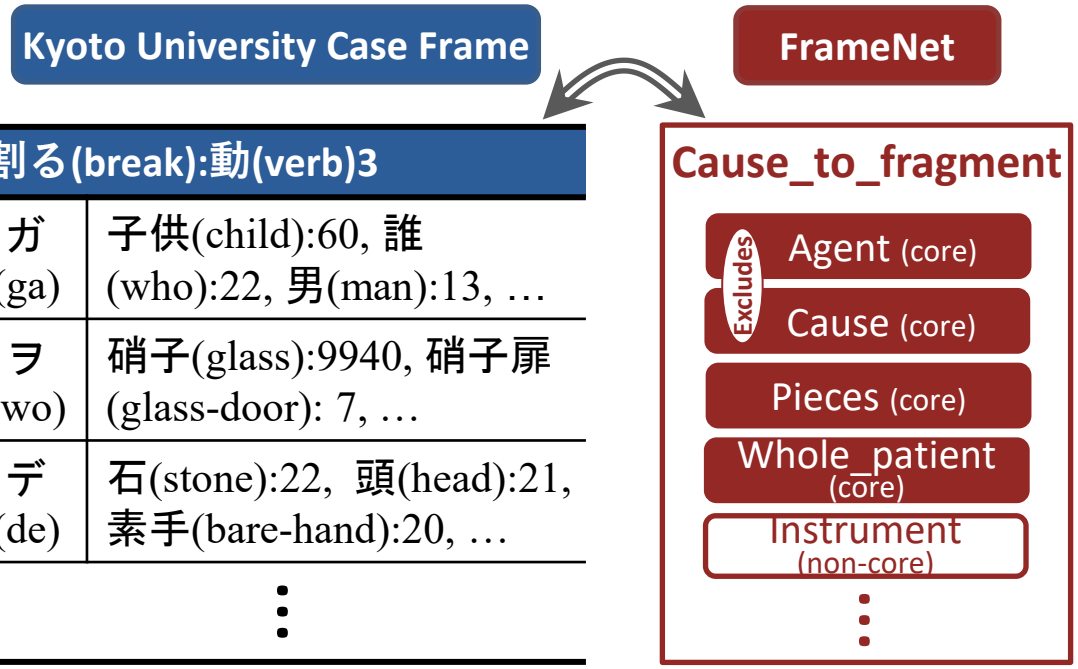


➢ Manual Development of Frame Resources

- Labor-intensive process
  - Especially associating with frames in other languages is difficult
  - Japanese FrameNet (JFN) (Ohara'13) has been developed for 20 years, but its coverage is still limited
- The process can be facilitated
  - if there is a base frame resource associated with FrameNet

We attempt to link KCF to FrameNet automatically

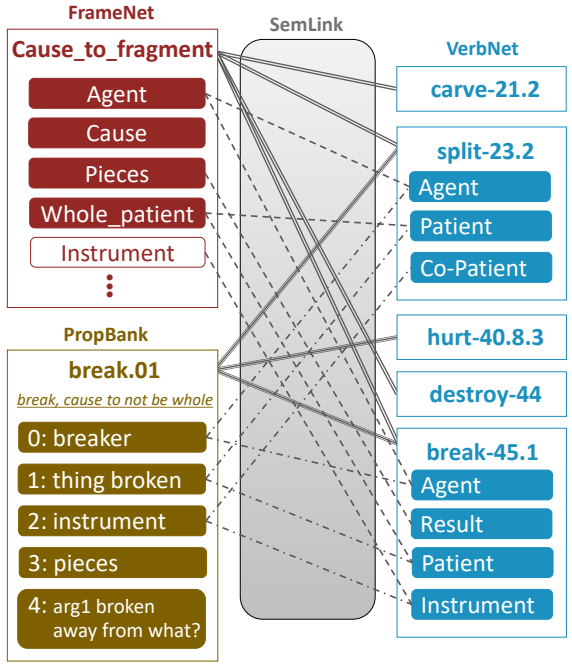
	FrameNet	JFN
# of cognitive frames	1222	947
# of lexical units (LUs)	13572	4957
# of annotated sentences	200751	7905



2. Related Work

➢ Linking frame knowledge

- SemLink (Palmer+'09) manually connects PropBank, VerbNet, and FrameNet
- (Ohara+'18) linked KCF with JFN using crowdsourcing
  - Linking automatically constructed lexicalized frames to manually crafted knowledge
  - Similar to our setting, but not cross-lingual



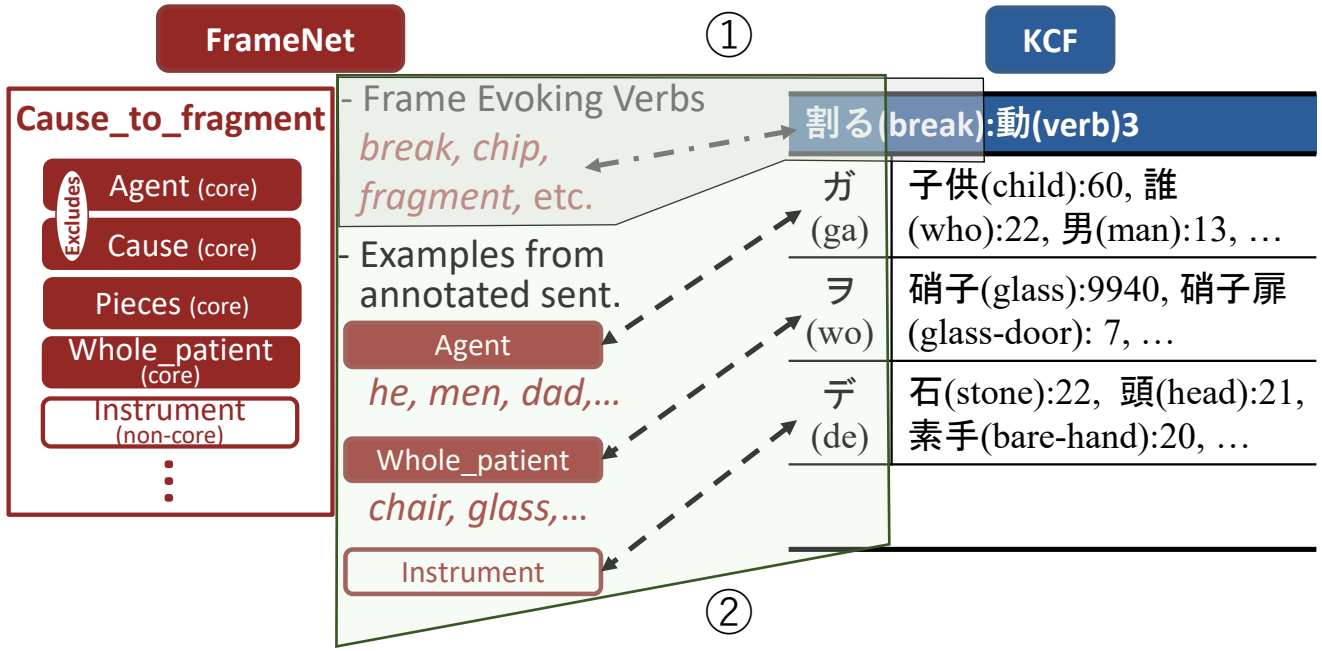
➢ Annotation projection

- Popular framework for transferring frame knowledge to other languages (e.g., Pado+'09, Akbik+'15, data. Yang+'18, Marzinotto'20)
- Exploiting the structural equivalences present in parallel corpora

3. Cross-lingual Frame Linking

➢ Overview

- We link each KCF frame to one of the FrameNet frames
  - KCF frames included in KNP 4.19 (https://nlp.ist.i.kyoto-u.ac.jp/?KNP)
  - FrameNet 1.7 (Ruppenhofer+'16) : Frame evoking words, called lexical units (LUs), and instances of frame elements (FEs) are extracted from the frame annotated sentences as the preprocessing
- Two steps
  ① Extracting candidate frames by taking only the verb into account
  ② Finding an alignment between a KCF frame and a FrameNet frame by also considering FEs

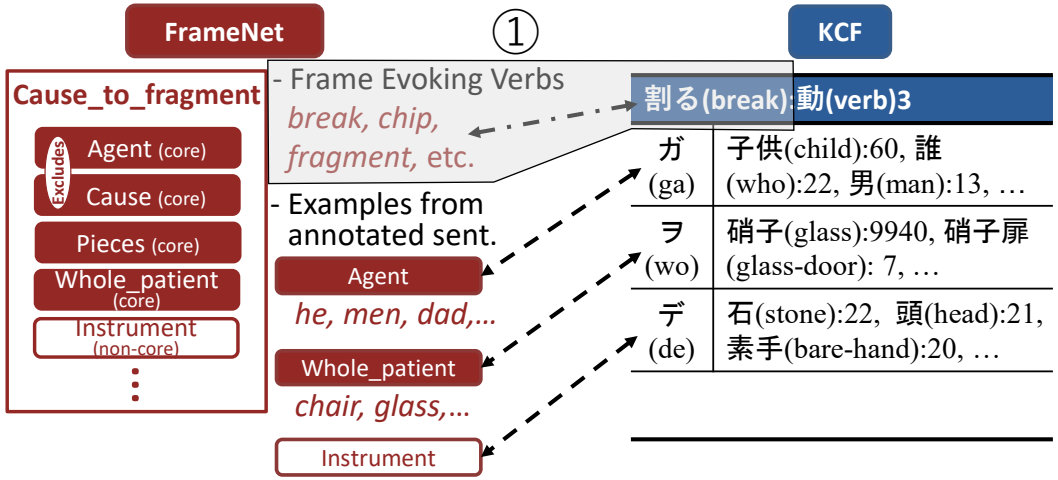


➢ Candidate Frame Extraction

- Extracting candidate frames by only considering the verb
  - When given a KCF frame CF_{v_j}, we calculate $\mathrm{sim}(v_j, LU_i)$, a cross-lingual similarity between verb v_j and each of the LUs of FrameNet frame FN_i
  - We use the top three cosine similarities of supervised cross-lingual word embeddings (https://github.com/facebookresearch/MUSE) as $\mathrm{sim}(v_j, LU_i)$

- Ranking the FrameNet frames
  - by the similarity score and extract the top 100 frames as the candidate frames for the given KCF frame CF_{v_j}
    - e.g., CF_{v_j} = 割る(break):3

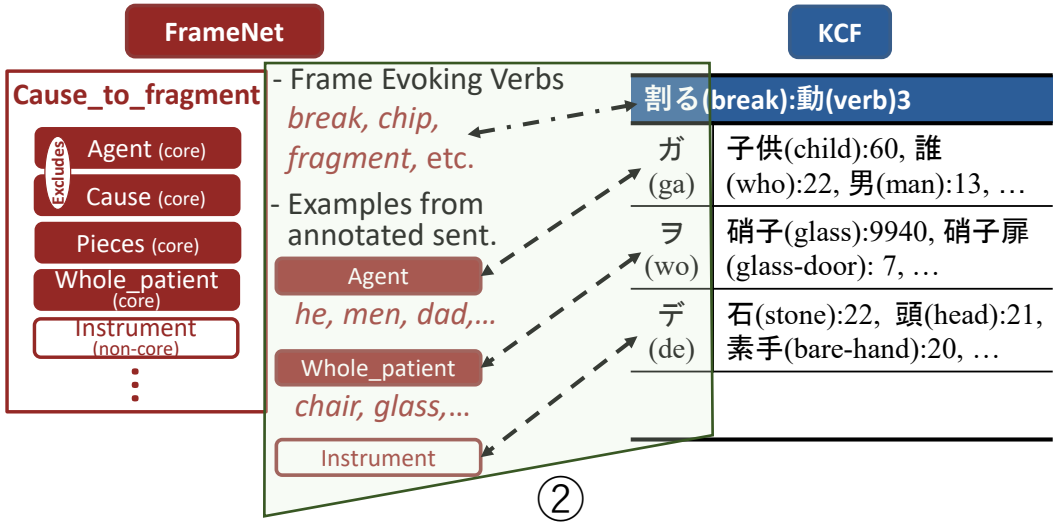
    ⇒ Cause_hram, Cause_to fragment, Impact, …



➢ Frame Alignment

- For each candidate FrameNet frames FN_i, we calculate the frame alignment score against the given KCF frame $CF_{v\,j}$
  - We use five Japanese surface cases as the target of the alignment, ガ(ga), ヲ(wo), ニ(ni), ト(to), and デ(de)
  - As for the FEs, we examined two settings

1. CORE-ONLY:
   Considering only the core FEs as the target of the alignment
2. ALL-FES:
   Considering both core and non-core FEs as the target of the alignment



- We calculate the alignment score for all combination of the pairs of target FEs and cases, with the following constraints
  - The ‘ga’ is always associated with one of the FEs
  - Two different cases are not allowed to be aligned to the same FE

- Alignment score is calculated as the product of $\mathrm{sim}(v_j, LU_i)$ and the sum of the individual case alignment scores $score(CA_k)$
  - $score(CA_k) = \cos\big(\mathrm{emb}(FE_m), \mathrm{emb}(c_n)\big) * \mathrm{wt}(c_n)$
  - $\mathrm{emb}(FE_m)$: the average of the embeddings that are included in the instances of the m-th FE
  - $\mathrm{emb}(c_n)$:the average of the embeddings that are included in the instances of the n-th case
  - $\mathrm{wt}(c_n)$: is the weight of case c_n defined as the square root of the total frequency of the case instances

- We take the highest alignment score for each FrameNet frame as the frame score and rank the FrameNet frames by their scores

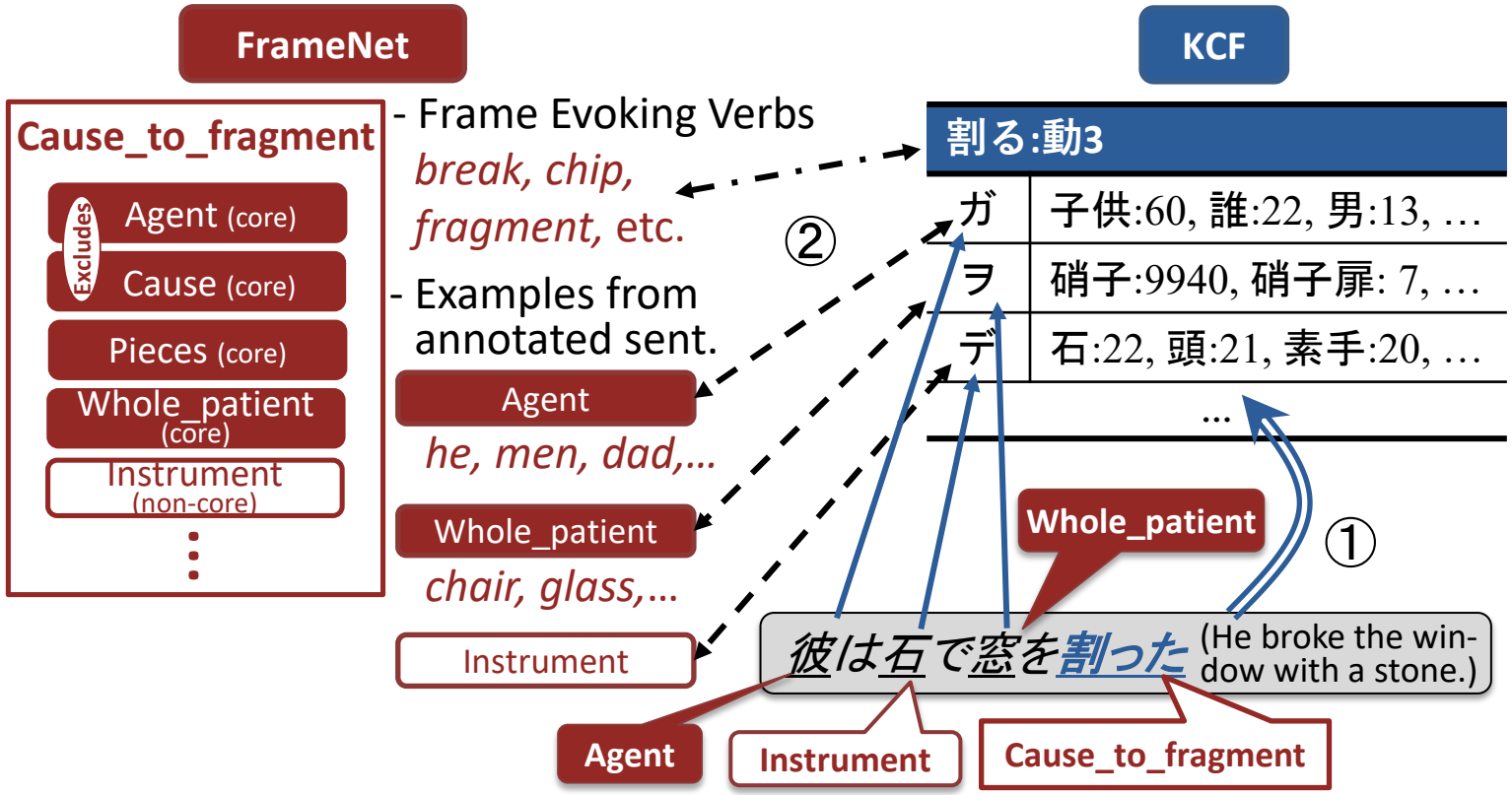
4. Experiments

➢ Evaluation

- No evaluation data for the link between KCF and FrameNet
- We use data from Japanese FrameNet, in which FrameNet frames are manually annotated to words in Japanese text
  - KNP, a Japanese predicate argument structure analyzer, can assign a KCF frame to each verb in Japanese text
  - If the frame to which the assigned KCF frame is linked matches the manually annotated frame, the link can be considered correct
- In this study, 1182 verbs from the annotated sentences in JFN were used for evaluation
  - We exclude those appearing as passive or compound verbs, so that the accuracy of the link itself could be evaluated

➢ Overview of the procedure for evaluation

1. Analyze predicate argument structure with KNP
2. Convert the KCF frame and its cases to a FrameNet frame and FEs



➢ Frame ranking results

Setting \ Recall	@1	@3	@5	@10	@30	@100
VERB-ONLY	0.367 (434/1182)	0.575 (680/1182)	0.629 (744/1182)	0.717 (847/1182)	0.804 (950/1182)	**0.910** (1076/1182)
CORE-ONLY	0.398 (471/1182)	0.573 (677/1182)	0.641 (758/1182)	0.719 (850/1182)	0.815 (963/1182)	**0.910** (1076/1182)
ALL-FES	**0.437** (517/1182)	**0.595** (703/1182)	**0.657** (777/1182)	**0.726** (858/1182)	**0.828** (979/1182)	**0.910** (1076/1182)

- We evaluated link accuracy by recall@k, the percentage of manually annotated frames that were ranked in the top k-th
- VERB-ONLY corresponds to the ranking for candidate frame extraction
- This result shows that taking FEs, including non-core FEs, into account was beneficial for ranking the FrameNet frames
- ALL-FES ranked the annotated frame in the top 5 for 65.7% and the top 10 for 72.6%, which would help the manual expansion of the frame-annotated sentences in JFN

5. Conclusion and Future Work

➢ Automatic linking of KCF and FrameNet

- To support the development of cross-lingual frame resources
- Both core and non-core FEs should be taken into account

➢ Future work

1. Using other kinds of cross-lingual word embeddings
2. Exploring the machine learning-based approach with additional features such as FrameNet hierarchy
3. Extending the scope of linking to non-verbal case frames
4. Exploiting our approach for manual expansion of JFN