Made of Steel?
Learning Plausible Materials for Components in the Vehicle Repair Domain

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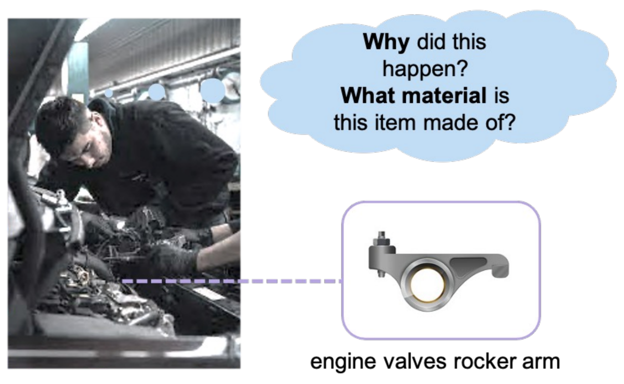
INTRODUCTION

As a standard approach, mechanics in vehicle repair shops often exploit the link between
- a component and
- a component's material



Crucial information for vehicle repair shops:
- Mechanics are faced with constantly growing vehicle complexity
- Plausible domain-specific material information typically not directly available

RESEARCH TASK: Automatically learn plausible materials in highly domain-specific contexts such as the vehicle repair domain.

DATA

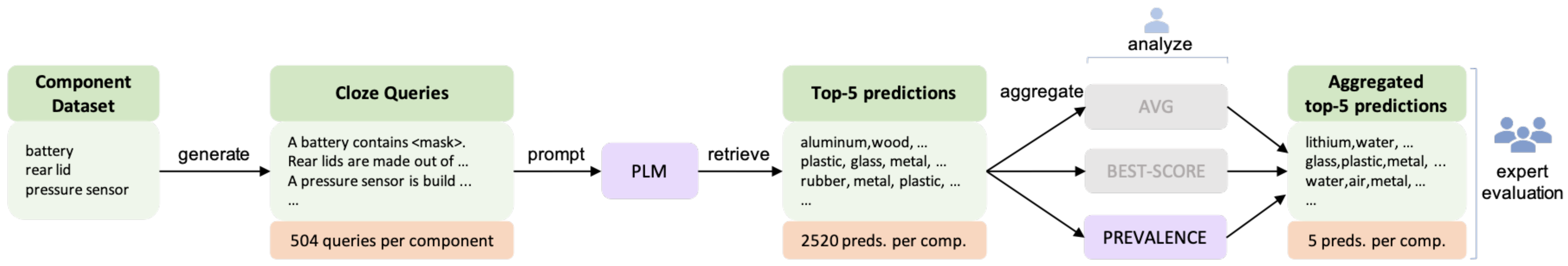
VEHICLE COMPONENT DATASET

- 7,069 expert-curated component names
  - Tangible physical components, e.g., *battery*, *cooling blower*
  - Intangible and functional components, e.g., *road test*
- 155 one-word components, 6,914 multi-word components with 725 right-most constituents as heads, e.g., *switch led* → *led*

DOMAIN-SPECIFIC CORPORA

- DOMAIN: high-quality vehicle repair manual by domain experts
- WIKI: portion of English Wikipedia customized to the domain

PRETRAINED LANGUAGE MODEL (PLM) EXPERIMENTS



Template: `[context]` + `[quantifier]` + indef. article + component + `[adverb]` + relation + <mask>. **Example:** A battery is made of <mask>.

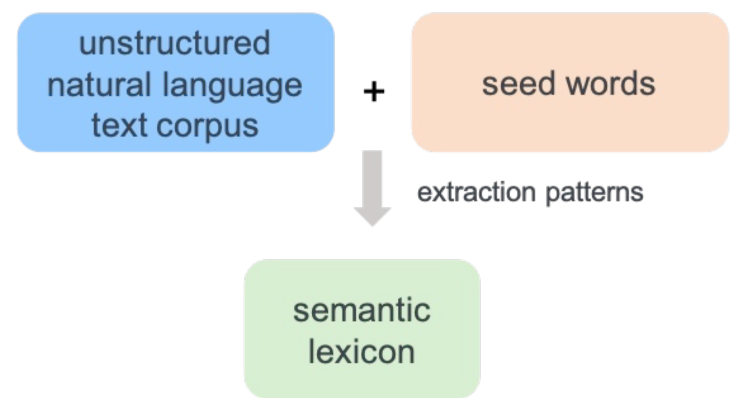
AGGREGATION METHOD development using Vanilla RoBERTa

- BEST-SCORE: aggregate most probable PLM-predicted material types from 2,520 top-5 predictions across all queries
- AVG: sum probabilities for each query variant on material type level and average by number of queries that predicted that material
- PREVALENCE: rank by how often material was predicted across all top-5 suggestions of all query variants

DOMAIN ADAPTATION

- Domain-adaptation of RoBERTa using Masked Language Modeling (DOMAIN-RB, WIKI-RB)
- Resource-leaner alternative: Train domain-adapted of DistilRoBERTa (DOMAIN DISTILRB)

A CLASSIC: BASILISK EXPERIMENTS



1. Determine seed nouns from semantic class material, e.g., *steel, metal, …*
2. Construct 396,887 domain-specific syntactic contextual patterns using dependency parsing on DOMAIN.
3. Apply Basilisk as bootstrapping algorithm to select best-performing patterns and fill candidate pool with extracted words.
4. Connect and generate up to 200 material candidates to components.

RESULTS

EVALUATION

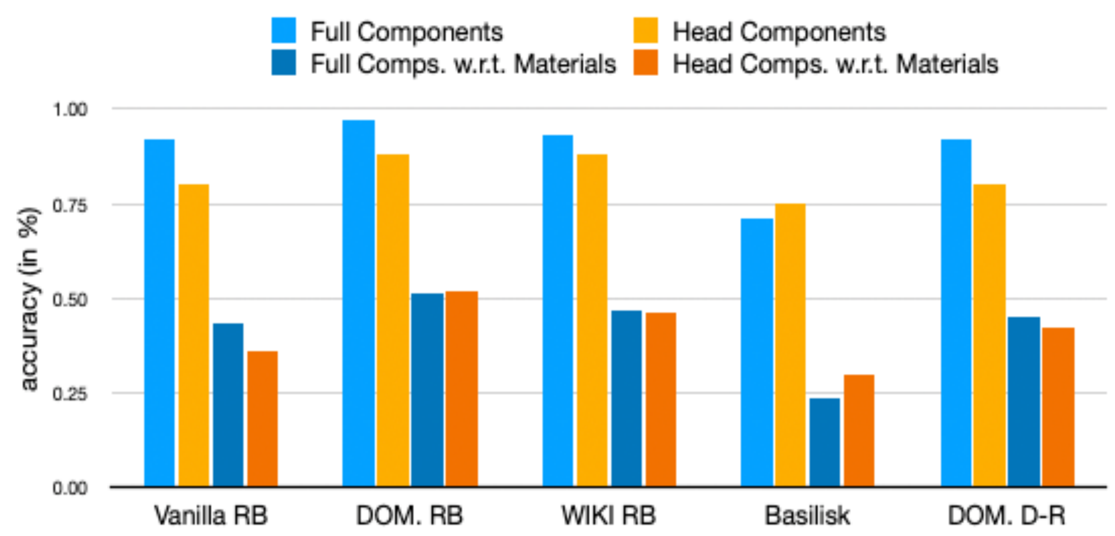
- Evaluation task with 3 domain experts as no annotated datasets are available
- Experts rate plausibility of top-5 material predictions for 100 vehicle components for four PLMs and the Basilisk algorithm
- Substantial pairwise Inter-Annotator Agreement is achieved (avg. 0.81)

	Components		Materials	
Model	$\geq 1A$	$3A$	$\geq 1A$	$3A$
VANILLA RB	0.87	0.68	0.49	0.24
DOMAIN RB	**0.93**	**0.73**	**0.62**	**0.28**
WIKI RB	0.91	0.66	0.56	0.24
BASILISK	0.73	0.40	0.45	0.14
DOMAIN DISTILRB	0.87	0.69	0.53	0.23

Vanilla RB	[wood, metal, steel, bones, legs]
WIKI RB	[wood, metal, steel, joints, aluminium]
DOMAIN RB	**[steel, metal, parts, aluminium, plastic]**
Basilisk	[structures, glass, core, steel, plating]
DOMAIN DistilRB	[steel, metal, parts, plastic, aluminium]

FINDINGS

- Domain adaptation boosts performance
- Small PLMs viable resource-lean option
- Domain-specific MWEs assumed to be largely compositional
- Comprehensive, domain-specific, and syntactically diverse cloze query set crucial for optimal results



Comparison of full and head component performance on component (full: x/59, head: x/40) and material (full: x/395, head: x/200) accuracy level.

ABLATION EXPERIMENT

- Create cloze queries using 5 frequent non-related full verbs (make, say, go, use, take)
- Results: only 9 correct materials are predicted; small number of sometimes semantically related types predicted for many components, for example: *fuel tank: [sense, noise, hydrogen, oil, cold]*

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CONCLUSIONS

- Tackled a **challenging task from material sciences** that are under-investigated from an NLP perspective
- Developed **novel approach to learn domain-specific plausible materials** by harnessing (i) standard PLMs and (ii) semi-automatically created cloze prompts combined with (iii) a suitable aggregation method
- Showed that **domain adaptation** using high-quality / customized Wikipedia corpora **boosts performance**