Semantic Product Search

Priyanka Nigam*
 prioritize@amazon.com
Amazon
Palo Alto, California, USA

Vihan Lakshman
vihan@amazon.com
Amazon
Palo Alto, California, USA

Choon Hui Teo
choonhui@amazon.com
Amazon
Palo Alto, California, USA

Yiwei Song*
ywsong@amazon.com
Amazon
Palo Alto, California, USA

Weitian (Allen) Ding†
weitian@andrew.cmu.edu
Carnegie Mellon University
Pittsburgh, Pennsylvania, USA

Hao Gu
hgu@amazon.com
Amazon
Palo Alto, California, USA

Vijai Mohan
vijaim@amazon.com
Amazon
Palo Alto, California, USA

Ankit Shingavi
ashingav@amazon.com
Amazon
Palo Alto, California, USA

Bing Yin
alexbyin@amazon.com
Amazon
Palo Alto, California, USA
Introduction

• It is important for an e-commerce website to enable customers discover products that match their shopping intent

• Every e-commerce website, like Amazon, has a catalog of products in their database:
  • The Amazon catalog contains over 9 billion products across all marketplaces
  • 17 marketplaces worldwide – 15 different languages
  • Each marketplace has its own taxonomy
Product Search Engine

- woman boots
- uggs woman boots
- woman boots black
- woman boots women
- woman boots combat
- woman boots hiking
- woman boots adult
- woman boots 8.5
- wonder woman boots

Lexical match

Inverted Index

Match sets

Ranking

Department
- Women's Boots
- Women's Ankles Boots & Booties
- Women's Mid-Calf Boots
- Women's Knee-High Boots
- Women's Snow Boots
- Women's Rain Footwear
- Women's Hiking Boots
- Women's Clothing
- Clothing: Shoes & Jewelry
- Sports & Outdoors
- Industrial & Scientific
- Home & Kitchen
- Grocery & Gourmet Food
- Tools & Home Improvement
- Automotive Parts & Accessories
- Pet Supplies
- Baby
- Beauty & Personal Care
- Everything Else
- Health, Household & Baby Care
- Garden & Outdoor
- Toys & Games
- Electronics
- Musical Instruments
- Arts, Crafts & Sewing

Did you mean woman boots

Price and other details may vary based on size and color

GLOBALWIN
Women's Fashion Boots

Sorel
Women's Explorer Joan

Koolaburra by UGG
Women's Victoria Tall Fashion Boot
Limitations of lexical matching

- Vocabulary mismatch
Limitations of lexical matching

- Vocabulary mismatch
- Spelling mismatch
Limitations of lexical matching

- Vocabulary mismatch
- Spelling mismatch
- Cross-lingual queries and products

“blusas azul rey para mujer”
(royal blue blouses for women)
Limitations of lexical matching

• Vocabulary mismatch
• Spelling mismatch
• Cross-lingual queries and products
• And many others:
  • Morphological variations
    • Woman vs Women vs Women’s (usually taken care by stemming/lemmatization)
  • Symbols
    • 4th => fourth
  • Abbreviations
    • LOL T-shirts
  • Numeric range
    • 3-5 years old
  • Measurement units
    • 1ft => 12 inches
Given rich customer behavior data, can we train a deep learning model to retrieve matching products in response to a query?

• Intuitively, there is reason to believe that customer behavior logs contain semantic information;
  • customers who are intent on purchasing a product circumvent the limitations of lexical matching by query reformulation or by deeper exploration of the search results.

• The challenge is the sheer magnitude of the data as well as the presence of noise,
  • a challenge that modern deep learning techniques address very effectively
Model Architecture

- Tokenization methods:
  - Word unigram
  - Word N-gram
  - Character Tri-gram
  - Handling unseen words
  - Combining all methods
Aggregation of different tokenization methods

- Bins = “hashing trick” popularized by Vowpal Wabbit to represent higher order n-grams that are not present in the vocabulary.

- In particular, hash out-of-vocabulary tokens to additional embedding bins.

- The combination of using a fixed hash function and shared embeddings ensures that unseen tokens that occur in both the query and document map to the same embedding vector.

Figure 5: Aggregation of different tokenization methods illustrated with the processing of “artistic iphone 6s case”
3-part Hinge Loss \( L(\hat{y}, y) := I^+(y) \cdot \ell_+(\hat{y}) + I^-(y) \cdot \ell_-(\hat{y}) + I^0(y) \cdot \ell_0(\hat{y}) \)

Define \( \hat{y} := \cos(E^Q, E^P) \), and let \( y = 1 \) if product \( P \) is purchased in response to query \( Q \), and \( y = 0 \) otherwise.

- where,
  - \( I^+(y) = \) product was purchased for a given query
  - \( I^-(y) = \) product was neither impressed nor purchased for a given query
  - \( I^0(y) = \) product was impressed but not purchased for a given query
  - \( \ell_+(y) := (\min(0, y - \epsilon_+))^m \)
  - \( \ell_-(y) := \max(0, y - \epsilon_-)^m \)
  - \( \ell_0(\hat{y}) := \max(0, \hat{y} - \epsilon_0)^m \)
Results

• At least 4.7% improvement in Recall@100 and 14.5% improvement in mean average precision (MAP) over baseline state-of-the-art semantic search methods using the same tokenization method.
• 3-part hinge loss outperforms other variants by deftly handling impressed but not purchased products
• hashing unseen tokens improves the precision across different tokenization strategies
• initial experiments using self-attention mechanisms and positional encodings did not show improvements in precision over the existing model, which underscores the unique nature of product search versus more traditional problems in IR and NLP.
Query: make it bake it suncatchers
Comments: Robustness to Spelling Error

Query: healthy shampoo
Comments: Associates sulfate-free to healthy

Query: collapsible step ladder
Comments: Synonymous intent

Query: ninjago lego training kai minifigure
Comments: Drops uninformative token "training"
What I did?

Semantic Product Classification

Did you mean women boots
Price and other details may vary based on size and color
Benefits

• Better search
• Better recommendation
• Better seller management
• Better misclassification detection etc.

Challenges

• 9 billion products – majority of them have wrong labels
• Positive signals are sparse
• There is not much information in query or in product
• Cross lingual domains
• Queries are shorter
• Positive signals (purchases) are sparser than clicks
• Shoppers may have multiple intents during a single search session:
  • a customer may be looking for a specific television model while also looking for accessories for this item at the lowest price and browsing additional products to qualify for free shipping.
Questions?