

ActionRec: Toward Action-Aware Recommender Systems on the Web^{*}

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Abstract. While actions that products enable their buyers to do are considered to play a significant role in purchase decisions, little attention is given to the integration of such actions in recommender systems. This work proposes the ActionRec framework, to semantically annotate the actions expressed by buyers in product reviews, and to capture the actions' linked entities in an openly accessible knowledge graph, which is used to develop action-aware recommendation apps. A web-based prototype is developed to demonstrate the potentials of integrating the annotated actions in a simulated product recommendations environment.

Keywords: Recommender Systems · Knowledge Graphs · Product Reviews · Semantic Web · Linked Data · Jobs-to-be-done.

1 Introduction

Recommender systems have been gaining research attention since products and services started to be exchanged on online platforms. Adomavicius et al. [1] identified that context-aware recommender systems that are able to capture and adopt user actions in the recommendation process would be ideal. Furthermore, needs-based recommender systems are seen as a promising approach to product recommendations [5]. However, interestingly, most recommender systems on e-commerce platforms still mainly derive context based on product features or user dimensions [4]. We observe that little attention is given to capturing actions that products enable their buyers to do, and integrating such actions in the recommendation process to better match products with consumer needs. This research attempts to address this challenge through a novel ActionRec framework.

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2 Approach: ActionRec Framework Components

Product text reviews contain a wealth of valuable information beyond the numeric ratings expressed by buyers. Part of this information constitutes potential actions that products enabled their buyers to perform. For example, a buyer may articulate in her review that she is very happy with the tablet that she bought, as it enabled her to *work* from home. Such expressed actions may fulfill the needs of other buyers and drive their buying decisions. In marketing, such buying decisions are often associated with the jobs-to-be-done concept, reflecting that customers tend to buy products to help them *do* a certain job [2,3]. In their jobs theory, Christensen et al. [2] highlight the importance of expressed actions by buyers to better understand their needs.

We propose ActionRec, a recommender system framework shown in Figure 1, to (1) capture the action-related entities in product text reviews through a *semantic annotator*; (2) represent and link the entities in a *knowledge graph*; and (3) employ the knowledge graph data to build *recommender apps*.

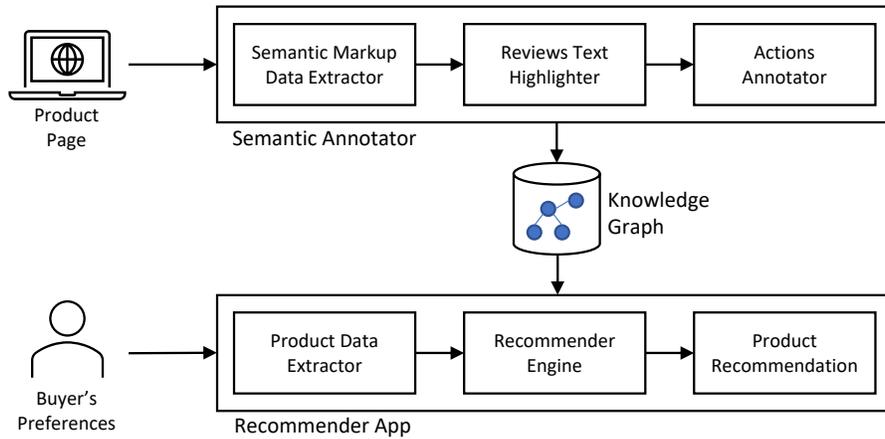


Fig. 1. High-level view of the ActionRec framework components.

Semantic Annotator. The semantic annotator component enables the annotation of product text reviews. It is currently implemented as a browser plugin to (1) automatically scan and extract relevant semantic markup data in product pages (e.g., description, offers, pictures, etc. as per Schema.org¹; (2) enable users to highlight text parts in the product reviews; and (3) annotate action-related elements (e.g., agent, environment, sentiment, etc.) The generated linked data is pushed to a triple-store hosting the knowledge graph.

Knowledge Graph. The knowledge graph is designed to connect the annotated text reviews to several entities including: *Things* such as *Products*, on which

¹ <https://schema.org/>

potential *Actions* can be performed by *Agents*, who have *Abilities* to use certain product *Features*, in a certain *Environment* such as location, and the expressed *Sentiments*. To maximize the linking of data, we reused and extended entities defined in existing vocabularies such as Schema.org and the Web Annotation Ontology². The data is accessible online³.

Recommender Apps. The knowledge graph data is used to develop apps that provide product recommendations while integrating the captured actions in the process. At a high level, the apps take into consideration the buyer’s specified preferences, combined with product data extracted from the knowledge graph through a SPARQL endpoint⁴. The extracted data is used by the recommender engine to display the recommended products and their related entities in the apps. Product recommendations can be provided by integrating product information about actions, review data, sentiments, and others, to assist online shoppers in their buying decisions.

3 ActionRec App Demo

We developed the ActionRec app, a web-based product recommendation prototype to demonstrate the potential integration of actions in the recommendation process⁵. Figure 2 shows a screenshot of the main features implemented.

The ActionRec app prototype relies purely on the knowledge graph data generated by the semantic annotator. So far, we have manually processed around 2,740 reviews of 9 computing devices from BestBuy⁶, with around 1,500 annotated actions. This generated around 58,500 triples in total. The prototype offers several features including:

- *List of Products:* The main window in the app (Part 1 of Figure 2) lists all the available products information available in the knowledge graph.
- *Most Relevant Actions:* In addition to the products’ feature details, the app displays the most prominent actions performed on the products (Part 2 of Figure 2). Such actions are detected by processing the knowledge graph data through a SPARQL query to extract the product, related actions, sentiment, and action count⁷. This data is used to compute the weighted ratio of positive sentiments out of the total expressed sentiments linked to this action. The weights of the actions are calculated based on the relative frequency of the actions performed on the product, extracted from the SPARQL query. For example, some of the most prominent actions performed on the Microsoft Surface Pro include “working,” “studying,” “carrying” and others. Clicking on the “more” link opens a tag cloud of actions.

² <https://www.w3.org/ns/oa>

³ Product data page example: https://linked.aub.edu.lb/actionrec/Product/PUV_00001

⁴ SPARQL endpoint and sample queries page: <https://linked.aub.edu.lb/actionrec/sparql>

⁵ The prototype is accessible online: <https://linked.aub.edu.lb/apps/actionrec/>

⁶ <https://www.bestbuy.com/>

⁷ The query is available on the SPARQL endpoint page.

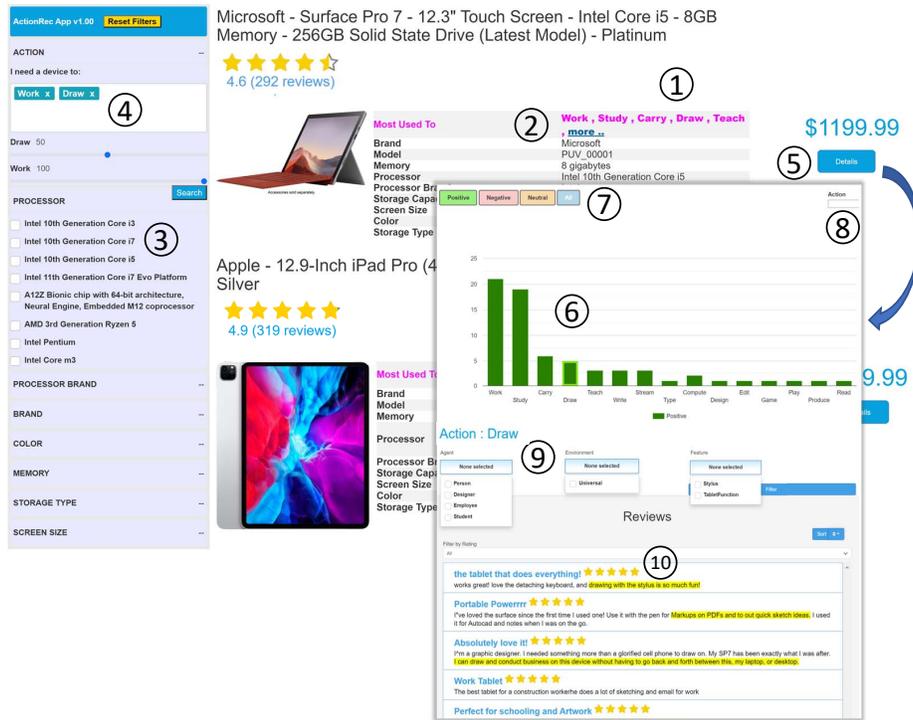


Fig. 2. Screenshot showing the main features of the ActionRec app prototype.

- *Action-based Filter*: On top of the regular feature-based filters shown in Part 3 of Figure 2, the app provides buyers the ability to find products that fulfill certain needs expressed in the form of *actions*. In Part 4, users can specify their needs through the actions they are looking to perform, e.g., “work” and “draw,” and the system will dynamically rank the products based on the products’ relative weighted average positive frequencies of the entered actions. The user can specify the importance of the action using a slider. For example, in the current data, the Apple iPad Pro ranks higher compared to the Microsoft Surface Pro with respect to *drawing* and *working* with equal importance. However, putting higher importance on *work* pushes the Surface Pro on top. The current SPARQL query fetches products that support *at least* one of the actions entered by the user, and ranks the products accordingly. The query can be adapted to match the selection of products that support *all* the actions entered.
- *Detailed Actions View*: The user can access a detailed view of the product by clicking on the “details” button in Part 5 of Figure 2. A new window will pop up, visualizing the actions and their frequencies in a bar chart (Part 6). The user can filter the actions based on the positive, negative, neutral sentiments (Part 7), or search for a specific action (Part 8). The bars in the chart

are clickable. For example, in Figure 2, the “draw” action is selected. Once clicked, the selected action’s linked “agents,” “environments,” and “product features” are extracted from the knowledge graph and displayed in Part 9. At this level, the buyer can select specific agents, environments, and features based on which the reviews and their annotations are filtered and displayed in Part 10. This way the reviews provide additional context to the annotated actions, and further assist the buyers in their purchase decisions in a more transparent and informed manner.

4 Conclusion and Future Directions

This paper demonstrated ActionRec, a novel approach for integrating the actions expressed in product reviews in the products recommendation process. The ActionRec framework includes a semantic annotator that helps with the automatic extraction of semantic markup data from product pages, enables users to highlight reviews, and annotate actions related to the products and other entities. The data is pushed to a publicly accessible knowledge graph, which can be used in recommender apps that process the action-related data to better match products with buyers’ needs and recommend products accordingly.

This research can be extended in several directions. First, the action filters to specify user needs can be extended to allow capturing additional context elements such as the actions’ objects (e.g., playing games versus playing music). Second, currently, the detection of actions is performed manually. This can be time-consuming and further work can be done on investigating the automation of actions and relations extraction from reviews. Third, a more detailed analysis of the approach would be needed to explore the potentials of the knowledge graph in performing certain recommendation tasks.

This work provides two contributions to the field. First, it contributes to showing the potentials of offering contextual product recommendations around the actions expressed in product reviews. Second, it provides an openly accessible knowledge graph that explicitly links user actions, products, and reviews context to computationally embed such data into the recommendation process.

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