

Ontology-driven context-aware recommendation method for indoor navigation in large hospitals

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Abstract. Navigating in complex and dynamic indoor spaces of large hospitals is challenging. Since improving efficiency is a common goal for hospitals, there is an urgent need for an accurate and personalized service recommendation method in hospital navigation. To address this challenge, we propose a context-aware recommendation method for personalized hospital navigation. Firstly, an ontology-based contextual framework is designed for hospital navigation using Protégé Web Ontology Language (OWL)-2. Then rule-based contextual reasoning and information recommendation using Semantic Web Rule Language (SWRL) are proposed to overcome the limitations of ontology reasoning. Finally, some case queries are conducted using RDF Query Language (SPARQL) to evaluate the usability of the contextual ontology and rules.

Keywords. Context-aware, Ontology, Recommendation, Hospital navigation, SWRL rule, OWL

Hospitals contain rich contextual semantic information, including critical medical knowledge and facilities, complex spatial layouts, hospital-related processes, and intensive information exchange (Moon & Kim, 2013). The complex and dynamic environment of the hospital consists of staff, patients,



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and devices that are constantly moving according to the changing healthcare tasks (Coyle, Neely, Nixon, & Quigley, 2006). Patients typically complete many tasks under time constraints and discomfort in large hospitals. Therefore, improving efficiency is a common need and goal for hospitals (Lakehal, Alti, Laborie, & Philippe, 2018). Much medical information and complex processes make location-based services recommendations challenging (Anagnostopoulos, Deriaz, Gaspoz, Konstantas, & Guessous, 2017). Compared to other indoor navigation (e.g., mall navigation, airport navigation), hospital navigation is unique which involves contextual information such as complex environments, user characteristics, medical processes, and medical knowledge. Specifically, different patients or groups (e.g., youth, elderly, newcomers, foreign visitors, immobility, people with various diseases) are heterogeneous. Therefore, they have different navigation needs and preferences (Ženka, Macháček, Michna, & Kořízek, 2021). Consequently, it is necessary to develop a context-based hospital navigation recommendation system to support user-centered services for personalized visits, rather than limited to traditional navigation from point A to point B.

Context-awareness plays a crucial role in the personalization and intelligence of navigation systems (Gartner, Huang, Millonig, Schmidt, & Ortag, 2011). Context-aware systems aim to improve computer-human interactions by using contextual information about the system, the user, and the environment (Lüddecke, Bergmann, & Schaefer, 2014). Previous studies develop various indoor applications based on context-awareness, such as indoor navigation (Afyouni, Ray, & Christophe, 2012; Huang & Gartner, 2009), location-related queries (Afyouni, Ilarri, Ray, & Claramunt, 2013), and recommended services (RSs) (Orciuoli & Parente, 2017). RSs have been an important research area of interest (del Carmen Rodríguez-Hernández & Ilarri, 2021). Intelligent RSs can generate personalized recommendations using contextual information describing the user's situation (e.g., individual, location, time, and tasks) (Adomavicius & Tuzhilin, 2011). Context-based recommendations can improve navigation efficiency and meet changing user needs (Villegas, Sánchez, Díaz-Cely, & Tamura, 2018).

Ontologies have attracted increasing interest as an essential means of modeling and reasoning about contextual information, especially in enhancing indoor semantic information to support indoor navigation, such as C-NGINE (Michou, Bikakis, Patkos, Antoniou, & Plexousakis, 2008), OntoNav (Anagnostopoulos, Tsetsos, & Kikiras, 2005), and CANE (Yao, Rolia, Basu, Singhal, & Kumar, 2012). Ontology-driven indoor navigation aims to provide semantic descriptions of certain events occurring in the indoor environment and support decision-making corresponding to recognized cases (Sriharee, 2015). However, there is limited research on intelligent hospital navigation services ontology for a personalized recommendation.

To address the above issues, this study proposes an ontology-driven context aware recommendation method to provide users personalized navigational information involving medical processes and knowledge. Firstly, a contextual ontology model is developed using Protégé Web Ontology Language (OWL)-2, consisting of user, time, location, indoor space, medical, process, and service. Then, a rule-based recommendation system is constructed using Semantic Web Rule Language (SWRL). Finally, the RDF Query Language (SPARQL) query service is utilized to evaluate the effectiveness of the recommendation method.

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