

NavCog3 in the Wild: Large-scale Blind Indoor Navigation Assistant with Semantic Features

DAISUKE SATO, IBM Research-Tokyo, Japan

URAN OH, JOÃO GUERREIRO, and DRAGAN AHMETOVIC, Carnegie Mellon University, USA

KAKUYA NAITO, Shimizu Corporation, Japan

HIRONOBU TAKAGI, IBM Research-Tokyo, Japan

KRIS M. KITANI, Carnegie Mellon University, USA

CHIEKO ASAKAWA, IBM Research, Carnegie Mellon University, USA

NavCog3 is a smartphone turn-by-turn navigation assistant system we developed specifically designed to enable independent navigation for people with visual impairments. Using off-the-shelf Bluetooth beacons installed in the surrounding environment and a commodity smartphone carried by the user, NavCog3 achieves unparalleled localization accuracy in real-world large-scale scenarios. By leveraging its accurate localization capabilities, NavCog3 guides the user through the environment and signals the presence of semantic features and points of interest in the vicinity (e.g., doorways, shops).

To assess the capability of NavCog3 to promote independent mobility of individuals with visual impairments, we deployed and evaluated the system in two challenging real-world scenarios. The first scenario demonstrated the scalability of the system, which was permanently installed in a five-story shopping mall spanning three buildings and a public underground area. During the study, 10 participants traversed three fixed routes, and 43 participants traversed free-choice routes across the environment. The second scenario validated the system's usability in the wild in a hotel complex temporarily equipped with NavCog3 during a conference for individuals with visual impairments. In the hotel, almost 14.2h of system usage data were collected from 37 unique users who performed 280 travels across the environment, for a total of 30,200m traversed.

CCS Concepts: • **Human-centered computing** → **Accessibility technologies**; • **Social and professional topics** → **People with disabilities**; • **Information systems** → *Location based services*;

Additional Key Words and Phrases: Indoor navigation, visual impairments, points of interest, voice interaction, user evaluation

This work was sponsored in part by JST CREST (Grant No. JPMJCR14E1) and NSF NRI (Grant No. 1637927).

Authors' addresses: D. Sato and H. Takagi, IBM Research-Tokyo, Hakozaki-cho 19-21, Nihombashi, Tokyo, 103-8510, Japan; emails: {dsato, takagih}@jp.ibm.com; U. Oh, J. Guerreiro, D. Ahmetovic, and K. M. Kitani, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, USA; emails: {uranoh, jpvguerreiro, dragan1, kkitani}@cmu.edu; K. Naito, Shimizu Corporation, Kyobashi 2-16-1, Tokyo, 104-8370, Japan; email: k.naito@shimz.co.jp; C. Asakawa, IBM Research, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA, 15213, USA; email: chiekoa@us.ibm.com; Daisuke Sato's current affiliation is Carnegie Mellon University, USA; email: daisukes@cmu.edu; Uran Oh's current affiliation is Ewha Womans University, South Korea; email: uran.oh@ewha.ac.kr; João Guerreiro's current affiliation is Instituto de Engenharia de Sistemas e Computadores, Investigação e Desenvolvimento, Lisboa, Portugal; email: jpvguerreiro@gmail.com; Dragan Ahmetovic's current affiliation is Università degli Studi di Milano, Italy; email: dragan.ahmetovic@unimi.it.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

© 2019 Association for Computing Machinery.

1936-7228/2019/08-ART14 \$15.00

<https://doi.org/10.1145/3340319>