

Informing Future Gesture Elicitation Studies for Interactive Applications that Use Radar Sensing

Santiago Villarreal-Narvaez

LouRIM

Université catholique de Louvain
Louvain-la-Neuve, Belgium
santiago.villarreal@uclouvain.be

Alexandru-Ionuț Șiean

MintViz Lab, MANSiD Center

Ștefan cel Mare University of Suceava
Suceava, Romania
alexandru.siean@usm.ro

Arthur Sluÿters

LouRIM

Université catholique de Louvain
Louvain-la-Neuve, Belgium
arthur.sluysters@uclouvain.be

Radu-Daniel Vatavu

MintViz Lab, MANSiD Center

Ștefan cel Mare University of Suceava
Suceava, Romania
radu.vatavu@usm.ro

Jean Vanderdonckt

LouRIM

Université catholique de Louvain
Louvain-la-Neuve, Belgium
jean.vanderdonckt@uclouvain.be

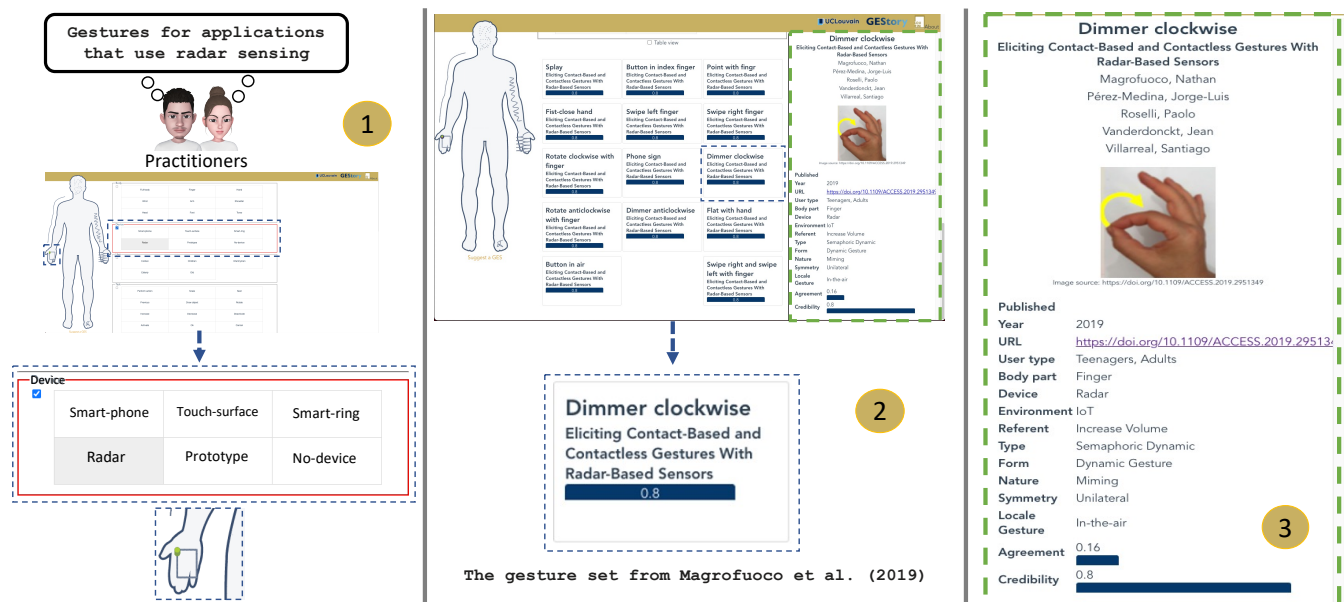


Figure 1: A query conducted in GESTORY to identify gestures for applications that use radar sensing.

ABSTRACT

We show how two recently introduced visual tools, REPLIGES and GESTORY, can be used conjointly to inform possible replications of Gesture Elicitation Studies (GES) with a case study centered on gestures that can be sensed with radars. Starting from a GES identified in GESTORY, we employ the dimensions of the REPLIGES space to enumerate eight possible ways to replicate that study towards

gaining new insights into end user's preferences for gesture-based interaction for applications that use radar sensors.

CCS CONCEPTS

• **Human-centered computing** → **Gestural input**; *User interface design*; *Participatory design*; *Empirical studies in interaction design*.

KEYWORDS

Gesture elicitation studies, reproducibility, radars

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1 INTRODUCTION

Gesture elicitation studies (GES) [13, 14] represent a fruitful method to uncover end users' preferences for interactive gesture commands, and have been applied for a variety of gesture types, devices, and applications [11]. While some application domains have been studied more closely, others are still to be examined. Among the latter, we note the paucity of GES involving gestures sensed with radars, despite the many applications of such sensors [6, 11] and the recent interest for their use for new applications in HCI [16]. In this paper, we show how REPLIGES and GESTORY [4], two recently introduced visual tools for GES, can be used conjointly to inform new designs of GES about radar gestures.

2 RADAR GESTURES

Radars are convenient for gesture sensing since they work effectively in a variety of conditions, including low light, darkness, adverse weather, and occlusion [2, 7, 16]. Figure 2 shows two examples of mid-air gestures that can be sensed with a radar. Prior work has introduced and evaluated various gesture recognition techniques for interactions enabled by radars, mostly based on deep learning approaches. For example, Soli [5] is a millimeter-wave radar sensor with sub-millimetre gesture tracking accuracy; RadarCat [15] is a radar-based system that recognizes materials and objects; Wang et al. [12] used high-frequency short-range radars for recognizing fine finger gestures using an end-to-end trained combination of Convolutional and Recurrent Neural Networks; and Sluÿters et al. [8] introduced a processing pipeline for hand gesture recognition that combined full-wave electromagnetic modelling and inversion with pattern matching. We refer to Ahmed et al. [1] for a review of hand gesture recognition with radars in HCI.

3 USING GESTORY AND REPLIGES

In a first stage, we used GESTORY [4] to identify end-user gesture elicitation studies conducted to understand users' preferences for gesture commands and corresponding mental models of gesture-based interaction for applications involving radar sensing. We performed a query in the electronic database of GESTORY (a total number of 216 records) using the "Device" filter option (Figure 1-1), which resulted in just one study [6] consisting of fourteen gesture types (Figure 1-2). Magrofuoco et al. [6] conducted their GES for radar gestures in the context of controlling IoT devices that involved 25 participants and a confirmatory study with 20 participants. The authors analyzed micro-gestures performed with the hands and fingers, and compiled a consensus set of 19 gestures¹ using the agreement rate measure [10]. Figure 1-3 displays information about one of the gestures from that study.

In a second stage, we used REPLIGES [4] to identify possible types of replication, extension, and continuation of Magrofuoco et al.'s [6] GES about radar gestures, as follows:

- (1) *Repeatability*. The objective is to reanalyze the data using the same method to confirm the results from [6].
- (2) *Reproducibility*. The collected data is analyzed with a new method, such as the dissimilarity-consensus technique [9].

¹GESTORY lists 14 gestures for the study of Magrofuoco et al. [6] instead of 19, because one of the gestures was assigned to multiple referents.

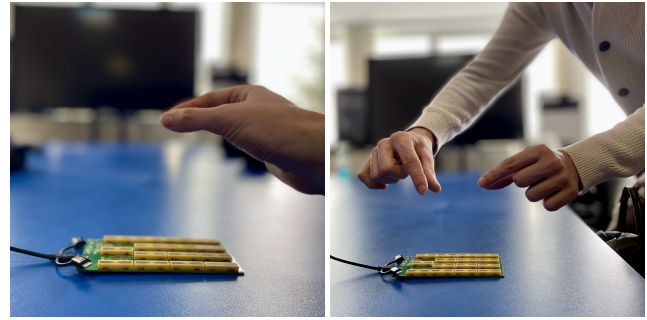


Figure 2: Examples of two gestures, a single-handed and a bi-manual pinch performed in mid-air, that can be sensed with a radar. In these photographs, the Walabot radar is visibly shown for exemplification purposes, but the radar could be hidden away, e.g., placed under the table.

- (3) *Replicability*. Using the same participants to collect new data is difficult, if not impossible. However, a confirmatory study, such as that from [6], can be conducted more easily.
- (4) *Extensibility*. A new method for gesture elicitation and/or analysis is used with new participants. For example, the Walabot radar (Figure 2) is presented to the participants, but the elicitation implements a Wizard of Oz study [3].
- (5) *Generalizability*. The same methodology of the original GES is applied to elicit and analyze gestures suggested by a different category of end users than employed in the original study [6], such as old people, children, people with motor impairments, etc., to understand whether the results, e.g., the consensus gesture set, are consistent between user groups.
- (6) *Extensibility and generalizability*. This replication may combine the Wizard of Oz study (see variant no. 4) and a new category of end users (variant no. 5).
- (7) *Repurposability (same population)*. The gestures elicited in the original study are repurposed to serve as a dataset for evaluating the accuracy rate of gesture recognizers.
- (8) *Repurposability (new population)*. The gestures elicited in the original study are used for insights to inform the design of new GES addressing the needs a new population, e.g., different users that might articulate the same gestures differently and for which a new sensor or a better performing sensor (e.g., a radar with a higher resolution) might be needed.

4 CONCLUSION

We showed in this paper how GESTORY and REPLIGES [4] can be used conjointly to arrive at various possible replications of a GES [6] for applications that use radar sensing. Future work will focus on conducting such replications to complete the existing knowledge from the community regarding end users' preferences for gestures that can be sensed with radars.

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