"For almost 30 years, I have engineered user interfaces for interactive systems for the ultimate benefit of the end user, without forgetting designers and developers."

Designing, Engineering, and Evaluating Gesture User Interfaces

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"All my theoretical and technical developments have the ultimate goal of understanding the user or, better put, the human caught in the middle of fast-developing technology. Understanding fundamental human characteristics and designing for those characteristics are the most worthy goals I can imagine as an HCI researcher."

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Abstract
This course will introduce participants to the three main stages of the development life cycle of gesture-based interactions: (i) how to design a gesture user interface (UI) by carefully considering key aspects, such as gesture recognition techniques, variability in gesture articulation, properties of invariance (sampling, direction, position, scale, rotation), and good practices for gesture set design, (ii) how to implement a gesture UI with existing recognizers, software architecture, and libraries, and (iii) how to evaluate a gesture user interface with the help of various metrics of user performance. The course will also cover a discussion about the wide range of gestures, such as touch, finger, wrist, hand, arm, and whole-body gestures. Participants will be **engaged** to try out various tools on their own laptops and will leave the course with a set of useful resources for prototyping and evaluating gesture-based interactions in their own projects.

Author Keywords
Gesture user interfaces, gesture recognition, engineering interactive systems, user interface design, gesture analysis, gesture production, methodology.

ACM Classification Keywords
H.5. Information Interfaces and Presentation: User Interfaces.

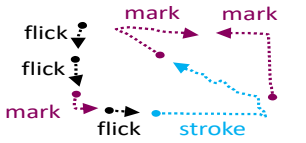

Fig. 1. Stroke gestures.


Fig. 2. Gesture input devices.

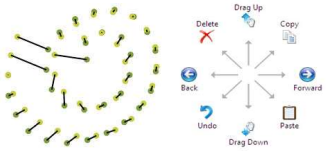

Fig. 3. Gesture recognizers.

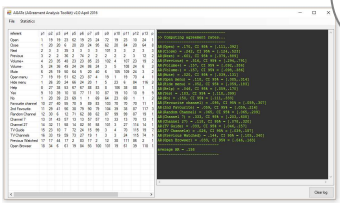
Fig. 4. AGATE Software support.

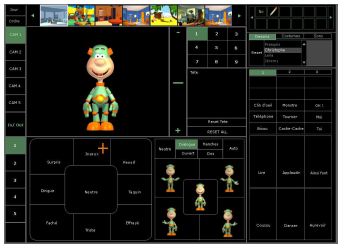
Fig. 5. A real-world project.

Course outline and schedule

The course consists in three parts that will introduce participants to (1) concepts useful for designing *gesture user interfaces* [21] for various contexts of use (*e.g.*, users [20], platforms, and environments), (2) models, methods, and techniques for incorporating gesture interaction into mainstream UI development, including gesture recognizers, and (3) practical tools to evaluate user performance with gesture input. Many examples will be discussed and practical tools will be demonstrated to the audience. The course will be offered as two sessions of 80 minutes each, pointing participants in a concise manner to the most relevant aspects of gesture interaction for each stage of the development life cycle of a gesture user interface.

1 Gesture UI design (50 minutes)

More and more digital products and services will support gesture input for many reasons [13]: human beings naturally produce gestures with various meaning, interpretations, and goals depending on their context of use; gestures are native, natural, and intuitive; gestures eliminate middleware devices like the mouse or keyboard; in a multimodal context, gestures provide a richer user experience than classical user interfaces. After defining gestures based on existing taxonomies, we will introduce, motivate, and discuss fundamental concepts for gesture interaction, such as (Fig. 1) [3]: flicks, marks, strokes, gesture recognizers, gesture articulation variability [1], properties of invariance (sampling, stroke, direction, position, scale, rotation), gesture set, training set, lagging, elicitation study. Participants will be provided with a concise survey of the most relevant aspects of the literature pertaining to gesture interaction.

2 Engineering Gesture UIs (30 minutes)

Today's large adoption of gesture interfaces, mostly prevalent on smart devices and gadgets puts a lot of demands on practitioners that need efficient recognizers to classify users' gesture input fast and accurately. The main technologies available today to acquire human gestures will be briefly presented (see Fig. 2): worn and hand-held equipment (*e.g.*, motion sensing controllers, gloves, mobile phones and devices) and non-invasive solutions (*e.g.*, video cameras). Simple and efficient gesture recognizers, such as, but not limited to, $1 [22], $N [2], $P [18], $P+ [23], LVS [9] (see Fig. 3) will be pointed to participants. Out of these, the $P gesture recognizer was found to be very accurate for a wide range of gesture types, yet it is simple to implement on any platform in about 70 lines of code [18] and is easily extendable to multi-touch input [14]. A reference software architecture will be exemplified and instantiated for several real-world projects already conducted. Software support for implementation will also be demonstrated: toolkits, libraries, and gesture managers (*e.g.*, UsiGesture [4]).

3 Gesture UI evaluation (80 minutes)

Careful analysis of users' gesture articulations can generate a lot of useful data to inform design of robust recognition approaches, gesture sets, and adaptive user interfaces. Gesture analysis can be performed in many ways, such as evaluating users' consistency of articulating gestures [1], using numerical features to describe gesture geometry and kinematics [11], and using appropriate visualizations to understand variation in gesture articulation [15]. Gesture elicitation studies [22] represent an instance of participatory design, during which participants (*e.g.*, end users representative of the target user population) propose gesture

Course history
This new course offers an integrated approach for developing gesture interaction, from design to evaluation by merging two prior courses: (**1**) A CHI'17 course entitled *"Fundamentals of Gesture Production, Recognition, and Analysis,"* which itself built upon a CHI'16 course focused on augmented reality, ambient intelligence, and gesture interfaces, and several courses offered at ACM TVX'14 and TVX'15, Euro-ITV'12 and EuroITV '13 under the title "*Designing Gestural Interfaces for Future Home Entertainment Environments*"; (**2**) An IEEE RCIS'16 tutorial entitled *"Gestures for Information Systems"* which itself was based on a course addressing the software engineering of gesture interaction. This new course also incorporates and reports experience from several real-world projects, such as gesture UIs for an Asian restaurant [6], 2D/3D navigation, virtual puppet animation in pediatrics (Fig. 5), and sketching [8,10].

commands that they believe represent good fit to effect application functions [15] (Fig. 4). Design criteria for gestures, such as ease of execution and perceived gesture difficulty [19], accuracy [17], learnability and memorability [12], time efficiency [3], performance [7], benchmarking [6], complexity [10], prediction [19], and gesture fit-to-function [13,23] will be explained and exemplified to participants with references from the relevant literature. Design guidelines will be provided to participants.

Instructors

The course will be delivered by Jean Vanderdonckt and Radu-Daniel Vatavu.

Jean Vanderdonckt, Ph.D., works in Human-Computer Interaction with focus on Engineering Interactive Computing Systems (EICS). Examples of the instructor's research and development experience relevant for this course are gesture recognition algorithms [6,9], gesture management environments [4], and software engineering methodologies [5].

Teaching experience
Jean Vanderdonckt is a Full Professor at the Louvain School of Management of the Université catholique de Louvain, where he teaches Human-Computer Interaction, Information Systems, Model-based User Interface Design and Development for undergraduate and graduate MBA and MSc students since 1998. He is an ACM Distinguished Speaker and Scientist (2017).

Radu-Daniel Vatavu, Ph.D., works in Human-Computer Interaction with focus on designing novel interactions and gesture user interfaces. Examples of the instructor's research expertise relevant for this course are gesture recognition algorithms [14,18], gesture analysis tools [1,15,16,17] and gesture methodologies [19].

Teaching experience
Radu-Daniel Vatavu is a Professor at the Computer Science Department of the University of Suceava, where he has been teaching Algorithms Design, Pattern Recognition, Advanced Programming, and Advanced Artificial Intelligence for undergraduate and graduate students since 2008.

Together, the two course instructors will provide delegates with a comprehensive overview of today's best practices for designing, engineering, and evaluating gesture user interfaces. To this end, the course aims to introduce more researchers and practitioners to the hot topic of gesture-based interaction, which will have a positive impact on user input and experience with future devices and gadgets.

Acknowledgements

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Target attendees
Researchers and practitioners working in general Human-Computer Interaction, user interfaces, and interaction design. A mixture of participants from research and industry is ideal. No previous knowledge about gesture interaction is required.

Presentation format
PowerPoint slides, videos, and demonstrations of tools. Course notes will be offered to participants, pointing to literature references and other course resources, such as code, packages, and toolkits.

Teaching methods
The instructors will employ presentation, working with examples, and discussion. Participants will be engaged by themselves by down-loading and running gesture software on their own laptop computers.

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