Declarative Physicomimetics for Tangible Swarm Application Development

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Emerging interest in exploring proximal Human-Swarm Interaction has started approaching the Human-Computer Interaction (HCI) vision of tangible, bidirectional interaction with intelligent swarms made up of “radical atoms” \cite{2}. The recent years have witnessed significant progress towards these once-hypothetical materials in the form of Tangible Swarm Robots, for which the focus shifted towards developing \textit{applications} for the user to interact with, rather than \textit{controllers} for the robots to solve tasks. Still, how and with which tools HCI designers could build such applications in a swift and reusable manner is an open issue.

We propose here such an application development framework which combines two existing approaches: First, we program swarms with \textit{virtual forces} that describe and create robot motion (\textit{i.e.} physicomimetics \cite{4}) instead of coding individual or collective actions over time. Second, we use the Qt Modeling Language (QML) \cite{1}, a declarative programming language originally designed to develop graphical user interfaces by \textit{declaring} objects and \textit{binding} their \textit{properties} and \textit{events} to create the program’s structure and flow. Our core idea is to define the swarm of robots and their behaviors (forces, tangible input detectors \textit{etc.}) in terms of these modular and reusable constructs. Below, we provide the program for a rudimentary “bubble shooter” game that illustrates this (details such as calibration values and game logic omitted), see Fig. 1 for its operation.

\textbf{Fig. 1.} Bubble shooter game with Cellulo platform \cite{3} where the goal is \textit{e.g.} to build the largest group of the same color. Launched robots collide elastically with existing robots (all 3 figures) and the walls (middle and right) before stopping.
The resulting programs are concise and contain no robotic implementation details, hiding what is uninteresting from the HCI perspective and exposing what is essential. However, our approach is centralized and cannot be readily applied to many existing platforms who do not guarantee global awareness. Moreover, developers must design and/or tune the desired forces, which may not be trivial.

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References