Studies in
Material Thinking

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**Volume 08**
**Experimental Arts**

# Multi-objective evaluation of cross-disciplinary experimental research

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*Abstract: Cross-disciplinary research involving experimental demonstration of an artwork poses many questions as to how the research should be viewed, measured and finally evaluated. Any evaluation necessarily imposes, to some extent, the framework of the evaluator, whether from the art world, from academia or from a funding agency. In this paper, Mari Velonaki will draw on her eight years' experience working as a researcher and artist at the Australian Centre for Field Robotics to highlight different views of validation of experimental research. Pragmatically, cross-disciplinary experimental research demands multi-objective evaluation. It is argued that projects of this nature can easily have multiple modes of success, multiple modes of failure, or an interesting mixture of successes and failures, when measured from different viewpoints. These projects are referred to as "multi-component" in the sense that they are composed from elements that work together to create a unity and yet, when separated, each component should still function independently—these projects are therefore amenable to deconstruction. The thread of collaboration between media artists and roboticists will be used to highlight the importance of developing a shared understanding and shared goals in multidisciplinary experimental research. When artists and roboticists work together from a research base that allows for experimentation they will commonly expand each other's research boundaries leading to the creation of new knowledge.*

*Keywords: Cross-disciplinary research, multi-objective projects, social robotics.*

**STUDIES IN MATERIAL THINKING**
http://www.materialthinking.org

ISSN: 1177-6234

Auckland University of Technology
First published in April 2007, Auckland, New Zealand.


**STUDIES IN MATERIAL THINKING** is a peer-reviewed research journal supported by an International Editorial Advisory Group and is listed in the Australian ERA 2012 Journal List (Excellence in Research for Australia).

# Multi-Objective Evaluation Of Cross-Disciplinary Experimental Research

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## Introduction And Background

In this paper I will discuss cross disciplinary research and multi-objective evaluation of outcomes, filtered though my eight year experience working in a robotics research group. I am a media artist and researcher and I work with robotics scientists.

Fig. 1: Fish-Bird: Circle B—Movement C (2005).

In 2003 I started working at the Australian Centre for Field Robotics (ACFR) as chief investigator on an Australian Research Council grant to develop the "Fish-Bird" project (Fig. 1). This was an interdisciplinary project that involved the creation of novel interfaces for human-robot interaction, experimentation in distributed sensory systems and robot "perception". For readers who are not familiar with the Fish-Bird project, a brief description from Velonaki & Rye (2010) is included below.

> "Fish-Bird" is an interactive autokinetic artwork that investigates the dialogical possibilities between two robots, in the form of wheelchairs, that can communicate with each other and with their audience through the modalities of movement and written text. The chairs write intimate letters on the floor, impersonating two characters (Fish and Bird) who fall in love but cannot be together due to "technical" difficulties.[1]

[1] The artwork was inspired by a contemporary Greek fairy tale about a fish and a bird who fall in love, but can't be together—one needs water, and the other air, to live. Nevertheless, they learn to coexist despite their differences.

What we've learned from the Fish-Bird project in relation to human-robot interaction, after 35,000 recorded encounters in five countries, is that behaviour is more important than appearance. Although Fish and Bird have the utilitarian appearance of an assistive device, participants were drawn to them because of the way they move and interact physically with them, and because of the handwritten style "personal" messages that they print for their audience.

We designed a data collection system that was implemented in the exhibition space and which recorded information in relation to participant's physical location and movement, proximity to the wheelchairs, time spent within the exhibition space, and messages received from the wheelchairs. It was observed in five countries (Austria, Australia, China, Denmark, USA) that people would tend to spend significantly more time close to Fish and Bird when they received more intimate, personalised messages from the characters that suggested a notion of fragility, despair or described incidents in the love affair between Fish and Bird. The average time spent by participants in the installation space was six minutes although, when more intimate messages were received, some participants interacted with the wheelchairs for more than 20 minutes.

The Fish-Bird project led to the creation of the Centre for Social Robotics, which I co-founded with David Rye in 2006. The Centre is dedicated to encouraging cross-disciplinary research by providing a space which allows for experimentation. Nine major projects have been realised at the Centre to date. In addition to Fish-Bird, these projects include "Diamandini" (2011–2013), an autonomous humanoid robot (see Velonaki, 2011), (Fig. 2); touch-sensitive artificial skin based on electrical impedance tomography (see Silvera Tawil, 2012); human cognitive workload assessment via physiological signal monitoring (see Brown, 2012); "Current State of Affairs" (2010), a reactive installation experimenting with real-time spatial sound manipulation and incorporating the elements of water and electricity (see Velonaki, 2010a); "Circle E: Fragile Balances" (2 009), an installation with a responsive kinetic object (see Velonaki, 2009a); dynamic Bayesian networks for understanding human movement mediated by interest (see Wood, 2011); "Circle D: Fragile Balances" (2008), an interactive installation with two autonomous objects (see Velonaki, 2010b); and "Embracement" (2003), a light-reactive installation incorporating a custom photodynamic crystal screen (see Velonaki, 2003).

Fig. 2: Diamandini (2011–2013).

## How Is Cross-Disciplinary Research: Viewed? Measured? Evaluated?

Before I answer these questions I have to add another one: by whom? The three prime candidates are: 1) art organisations, 2) academia and 3) research funding bodies. I will elaborate further from the perspective of an artist/researcher working in Australia.

The first group includes art galleries and museums, art-related funding bodies—for example, the Australia Council for the Arts or the NSW Ministry of the Arts. Obviously, it is essential that one's research is centred in the arts and involves the creation of an artwork. This is a case of practice-based research, the merits of which are validated through exhibiting the artwork. Important metrics in this case are the number of exhibitions, the status of the institutions that hold these exhibitions, historical context, peer evaluation and critical art reviews. In this case, academic publications and quantitative and/or qualitative analysis via the collection of data are obviously not of high priority.

The second grouping, academia, is a natural place for research to occur. One hopes that cross-disciplinary research activity will not only be accommodated but fostered and encouraged within an academic environment. In relation to evaluation, one must first gain acceptance and appreciation of his/her research by his/her peers.

Successful outcomes, as measured by both academic publications in high-quality journals and conferences and artworks classified as HERDC "major creative works" should lead to institutional support and academic promotion. In Australia, the Higher Education Research Data Collection (HERDC) is the determinant of additional "block" research funding to universities. HERDC funded publications are essentially written publications, including published arts conference proceedings—and therefore reports of the presentation of artworks in international forums. For example, Fish-Bird exhibitions (see Velonaki, 2004, 2006, 2009b) have provided quantitative and qualitative data that have lead to several publications (Velonaki & Rye, 2010; Velonaki, Scheding , Rye & Durrant-Whyte, 2008; Velonaki, Rye, Scheding & Williams, 2008 and Velonaki, Rye, Scheding & Williams, 2006).

An artwork that is accepted through a formal review process may be reported via HERDC as a major creative work—and in recent years, to the Excellence in Research Australia (ERA) evaluation conducted by the Australian Research Council (ARC) where it has the same weight as a book or journal article. This ERA recognition has in turn impacted on the publication categories formally recognised in researcher track record evaluation by the Australian Research Council (ARC). Judging from the number of questions that I receive during conferences in relation to academic evaluation of an artwork this is not widely known.

The third group, (at least in Australia) is the peak research funding body, the Australian Research Council. The ARC funds research, rather than the creation and exhibition of artworks. As in academia, the ARC measures research outcomes principally through a researcher's publication record. ARC-funded projects must contribute new knowledge to the field. If the project involves an artwork, the artwork can become the vehicle for answering research questions through experimental demonstration. Experimental demonstration involving the general public—for example, in a gallery or museum, where people move more freely and are open to experimentation—can help to collect valuable data, free of the restrictions inherent in a laboratory space. Participants in a gallery or museum can also be from a wider variety of social backgrounds and age groups than those who volunteer for laboratory-based studies. Access to data generated in social spaces spaces—spaces open to the general public—can be extraordinarily valuable to researchers in many varied disciplines.

In my work data are collected in two ways. Since my experimental installations are computer-controlled, the computers are used to log data on how participants move in a space, or how they handle an object. These data are sensed using transducers that are either built into the installation objects, or mounted in the installation space. In addition to the automated collection of quantitative data from within the installations themselves, I make use of personal observations when permissible in the installation space. These personal observations, although more satisfying to the artist because of their immediacy, pose the danger of altering the interactive behaviour of the participant when s/he realises that s/he is being observed.

In my experience, however, there has been significant progress in awareness, understanding and appreciation of this kind of experimental art practice and research from all three of the previously mentioned groups, especially over the last three years.

**Cross Disciplinary Research = Multi-Component Projects**

Cross-disciplinary experimental research demands multi-objective evaluation. It is argued that projects of this nature can easily have multiple modes of success, multiple modes of failure, or an interesting mixture of successes and failures, when measured from different viewpoints. These projects are referred to as "multi-component" in the sense that they are composed from elements that work together to create a unity and yet, when separated, each component should still functions independently—these projects are therefore amenable to deconstruction. Here, the term "multi-component" is used as a sub-category of "multidisciplinary". For example, a collaborative research project between the disciplines of visual arts and robotics is by definition multidisciplinary since it involves at least two disciplines. On closer inspection though, I feel that it is more appropriate to call this a multi-component project in order to emphasise the specific roles and contributions of each of the team members. Components may include: conceptualisation, sound design, human-machine interface design, mechatronic systems design, systems architecture, robot navigation and artificial vision systems. This thread of collaboration between media artists and roboticists is used to highlight the importance of developing a shared understanding and shared goals in multidisciplinary experimental research.

When working in a multidisciplinary team, the success of collaborative project is best measured by the scholarship of project outcomes. Here, scholarship is defined in terms of the following: knowledge of "best practice" in one's own discipline; the advancement of "best practice"; and the dissemination and uptake of the research outcomes by one's peers. True interdisciplinary collaboration demands that the disciplines of all contributors acknowledge and validate the work as a "scholarly contribution". That is, from the viewpoint of each discipline the research has "value," in making an original contribution to the field. It is important for a team to identify through discourse a clear, common goal and to commit as a group to attaining that goal. Team members should have their own individual goals that are not necessarily shared by the whole group. For example, the performance of tracking algorithms is of direct scientific interest to robotics researchers. For an artist, however, although tracking accuracy is important for the integrity of the system and therefore the smooth operation of the artwork, continued advancement of tracking algorithms is not a direct goal.

Although the above collaborative model is ideal, in my experience it is not always easily attainable. For example, when I work on a three-year ARC project it is imperative from the beginning that all investigators have an important role in the project to motivate their long-term commitment. On the other hand, it is still very important to me to work on smaller-scale projects where my collaborators may still have an advisory role without the project representing a research interest for them. In multidisciplinary collaborative work over extended time periods it is not realistic to expect that every single project will always contain equal amounts of research work from all collaborating disciplines.

Multidisciplinary projects can have additional, unexpected outcomes regarding re-application or commercialisation. For example, Professor Challa at the University of Technology, Sydney, adopted the sensing paradigm of the Fish-Bird system to improve safety in environments inhabited by people with of a range of sensory and motor abilities, such as nursing homes. In the Fish-Bird system the sensing technique customary in robotics, that of fitting sensors to the mobile robot, was inverted by installing the sensors at fixed locations in the space rather than the robot itself. A further example is the reapplication and commercialisation of the iCinema Advanced Visualisation and Interaction Environment (AVIE) technology by Professor Pagnucco and Professor Del Favero for mine safety-training simulators in China and Australia, to improve workers' safety.

Although re-application and/or commercialisation are positive outcomes, these must be regarded as bonuses rather than prerequisites for the justification of multidisciplinary research.

## Spaces Of Experimentation

In the case of the Centre for Social Robotics we wanted to create an environment dedicated to understanding interaction between humans and robots in socially empowered spaces. By "socially empowered spaces", I mean spaces where people can freely interact with a robot, unlike the constrained environment of a laboratory, and can therefore shift the dynamics of that space. To date, for our group these opportunities have existed almost exclusively in museums and galleries. In October 2011, I established the Creative Robotics Lab at NIEA

(COFA, University of New South Wales), a space that provides a cross-disciplinary research environment dedicated to understanding how humans can interact with robotic devices and structures within the context of experimental arts. The Creative Robotics Lab is in partnership with the Australian Centre for Field Robotics at the University of Sydney.

The inhomogeneous nature of these multi-objective projects demands dedicated spaces that provide appropriate technological infrastructure and a nurturing intellectual environment that encourages experimentation and appreciates the value of sometimes unpredictable outcomes.

These spaces allow for the expression of many voices: of artists, engineers, roboticists, AI experts, theorists and of participants from the general public, which will contribute to the development of new research directions. In the context of the development of robotics—the involvement of the arts and humanities is not merely complementary but essential. It is the key to the creation of systems that question and challenge our perception of what a robot can be and, at the same time, reveal interesting human behaviours when challenged by the technological "other".

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**Figures**

Fig. 1: Fish-Bird: Circle B—Movement C (2005).
Fig. 2: Diamandini, (2011-2013), autonomous humanoid robot.

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Mari Velonaki is a researcher and media artist who has worked in the field of interactive installation art since 1995. Her practice engages the spectator/participant with digital and robotic "characters" in interplays stimulated by sensory triggered interfaces. Her innovative human-machine interfaces promote intimate and immersive relationships between participants and interactive artworks. She was awarded a PhD in Media Arts at the College of Fine Arts, University of New South Wales in 2003. In that year, she was also awarded one of the two inaugural ARC Linkage/ Australia Council Synapse Awards (2003-2006). In 2006 she co-founded with David Rye the Centre for Social Robotics within the Australian Centre for Field Robotics at the University of Sydney. In 2007 Velonaki was awarded an Australia Council for the Arts Visual Arts Fellowship in recognition of her body of work. In 2009 she was awarded a prestigious Australian Research Council Queen Elizabeth II Fellowship (2009-2013) for the creation of a new interactive robotic form. This research investigates human-robot interactions in order to develop an understanding of the physicality that is possible between a human and a robot. Velonaki's installations have been exhibited widely, including: National Art Museum Beijing: Gyeonggi Museum of Modern Art, Korea; ZENDAI Museum of Modern Art, Shanghai; Wood Street Galleries, Pittsburgh; Millennium Museum, Beijing Biennale of Electronic Arts; Ars Electronica, Linz; Biennale of Electronic Arts, Perth; Adelaide Biennial of Australian Art; Conde Duque Museum, Madrid; European Media Arts Festival, Osnabrück; Te Papa Tongarewa Museum of New Zealand; Arco, Madrid; Museum of Contemporary Art, Sydney; Queensland Art Gallery/GOMA; Art Gallery of New South Wales; Ton-Build-Spektakel, Zurich; Aros Aarhus Museum of Modern Art, Denmark.