Computational Self-Awareness in Musical Robotic Systems

David Thorvaldsen

Thesis submitted for the degree of
Master in Informatics: Robotics and Intelligent Systems
60 credits

Institute for Informatics
Faculty of mathematics and natural sciences

UNIVERSITY OF OSLO

Autumn 2021

Computational Self-Awareness in Musical Robotic Systems

David Thorvaldsen

Computational Self-Awareness in Musical Robotic Systems

http://www.duo.uio.no/

Printed: Reprosentralen, University of Oslo

Abstract

INKL.: [What Is Self-Awareness, according to some of history's most prominent thinkers, including central philosophers and psychologists? Or first things first, what Is *the self*? And what Is *awareness*? What implications does this have as it pertains to the domain and practice of computer science and engineering — especially when designing and describing computing systems? What lessons can designers and researchers of computing systems learn, what can they be inspired by, and which benefits/advancements can be made when exploring the answers to these questions?]?

Acknowledgement(s$^{?}$)

Contents

List of Tables

List of Figures

1 Introduction

1.1 Motivation

GJØR: [Se om det er noe fra essayet og kommentarene i .tex-fila derfra som jeg vil gjenbruke her].

GJØR: [Tenk igjennom og besvar så godt som mulig etterhvert (kompilert fra Samuelsens MSc-thesis. Kan cross-checke med Tønnes og hun andres også):

- **Why is the thesis topic, and its outflowing proposed solutions/improvements, of relevance in the world today?**
  - History of field, how things have been done before — and why the situation/needs/requirements might have changed, or why these traditional/typical solutions may be ripe for improvements or better solutions? Why are these concerns/problems/factors of importance?
    - Demonstrate, illustrate, and explain these changes / this new situation so that the reader understands why your topic's contributions are necessary or needed.
  - What are the relevant real-world problems in need of solutions/improvement, where the thesis topic can provide such solutions/improvements?
  - Differentiate between what the "Background-/Related-works-proposed method" conributes with, and the "new proposed method" that you yourself want to try out (e.g. differentiate between ODA-loops and MAPE-K-loops, and endowing computational systems with *computational self-awareness* (and *self-expression*).
    - Explain why the "new proposed method" is needed/granted, maybe in relation to a lack or challenge with the original "Background-/Related-works-proposed method". Perhaps also mention the absence or "freshness" of this "new proposed method" in the history or field of the "Background-/Related-works-proposed method".

].

INKL.: [Engineering a computing system for a certain environment often requires some knowledge of said environement — both on the end of the creator of the computing system, as well as for the computing system in turn. This is at least the case in autonomous computing, where computing systems are supposed to be able to observe, learn, adapt, and act on their own — independently from their creator.]?

However, predicting all possible future states of complex, dynamic, and ever-changing environments is hard, and at times impossible. **INKL.:** [This calls for online and continuous learning, don't you think? How to best tackle this problem? Glad you asked. — With Self-Awareness of course. Because ...]?

1.2 Goal of the thesis

GJØR: [Kople tekst oppmot Research-Spørsmålene mine her].

1.3 Outline

GJØR: [Skriv opp strukturen/oversikten (Eagle's-eye) av thesis-dokumentet her].

2 Background

GJØR: [Skriv opp bulletpoints fra mulige inspirasjoner og referanser her].

INKL.: [Nymoen et al. [1] showed how one can, by endowing musical agents with self-awareness capabilities, achieve *harmonic synchrony* of phases and frequencies in pulse-coupled oscillators.]?

3 INKL.: [Tools and engineering]?

BESKR.: [(Hentet fra Tønnes sin master) En introduksjon til de forskjellige verktøyene og prosessene brukt iløpet av masteroppgaven. Fokuser på fysisk arbeid gjort, og ingeniør-delene av masteroppgaven, inkludert 3D-design av de fysiske robotene, valg av deler, simulering i systemer, og testingen, validiringen, og verifikasjonsmetoder brukt i oppgaven. Gjerne også en oversikts-tabell av verktøy og programvare brukt].

4 INKL.: [Proposed Algorithm?]?

BESKR.: [Metoden/Ideen bak mitt bidrag/forslag, forklart i detalj].

5 INKL.: [Benchmark]?

GJØR: [Vurder om denne seksjonen er tilsvarende som seksjonen 'Implementation'].

BESKR.: [(Hentet fra Samuelsens master?) Presentering av metoden brukt til å evaluere ytelsen av den foreslåtte/proposed'e algoritmen. Først er kanskje en referanse-algoritme brukt for sammenlikning beskrevet. Deretter er (f.eks. objektiv-) funksjoner brukt i testene forklart. Endelig (til slutt) er kanskje miljøene/environments'a og parameterne brukt presentert].

6 Implementation

GJØR: [Vurder om denne seksjonen er tilsvarende som seksjonen 'Benchmark'].

GJØR: [Skriv opp Worklog-materiale dandert i henhold til gode master-theses].

"Sigmund Kjøkken-Recall": [

GJØR: [Demonstrer/Illustrer poenget bak fingrene og tidsaksen på bordet

(ish det som er i figuren under for fase), og så det samme for frekvens-justering med f.eks. halve—eller noe annet—som start-frekvens; og at de da ender i *harmonisk synkroni*].

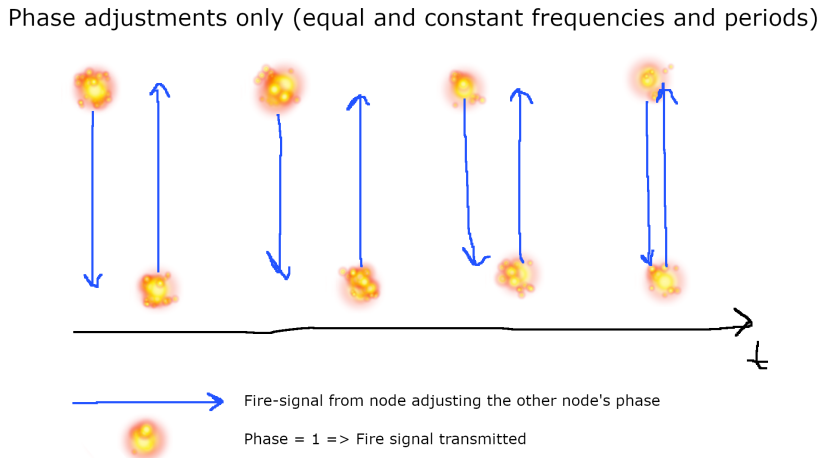

Figure 1: Fase-justering (som om man skulle tappet med fingrene på et bord)

].

"Tante-Kjersti-inspirert (ish Stue-Recall)": [

The diverse and complex phenomena of nature have for long served as exciting inspirations to human engineering and research (cite ant colonies, boids & swarms, beeclust e.g.). One such phenomena studied and attempted modelled is the synchronous firing of fireflies in the rainforests.

GJØR: [Insert illustration/picture of synchronizing/synchronized fireflies firing in a dark forest here].

This has inspired scientists like Mirollo & Strogatz [], and in later time Kristian Nymoen, Kyrre Glette et al. [1], to attempt to model and "etterlikne" this natural phenomenon in human-engineered systems. This work ties into the work on synchronizing oscillators []? which has been subject to study for some time now. What separates Mirollo & Strogatz and K. Nymoen's approach from these previous ones, is that here the oscillators are *pulse-coupled*, as opposed to the more normal and constraining *phase-coupled* (explain?). Each modelled "firefly", or firing node, is here implemented and considered as an oscillator, characterized by its phase and frequency. **INKL.:** [Kinda, the job is to align sinusoidal waves, either by shifting an agent's phase "up", or "down".]?

INKL.: [No training of any neural networks or any model-data was needed to achieve synchrony in this case — and so far no machine learning is used — but instead we see an emergent *harmonic synchrony* in a collective, by endowing fairly simple agents with not too complicated update-functions. This is

well known in the Multi-Agent Systems & Swarm Robotics literature []?.]?].

7 Experiments and Results

GJØR: [Vurder å dele opp som Tønnes: Først 1) Evolusjonære/Simulator? eksperimenter og resultater, så 2) Fysiske eksperiment og resultater].

8 Discussion

GJØR: [Se på Tønnes sin masteroppgave for inspirasjon].

References

[1] Kristian Nymoen et al. “Decentralized Harmonic Synchronization in Mobile Music Systems”. In: *Grant agreement no. 257906 (EPiCS) from EU FP7* (2014).