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Towards Real-Time Animation Optimisation in VR

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1. Introduction and Motivation

The advent of high-fidelity Virtual Reality (VR) allows us to experience virtual characters with an ever increasing sense of presence. VR is capable of enhancing the perception of many aspects of virtual characters, including their volume and texture, speed, weight and temperament. The intimate nature of such experiences also requires a greater attention to behavioural realism, player interaction and animation detail.

There is strong evidence to suggest that VR is capable of a much greater sense of immersion compared to viewing the same environment on a desktop monitor, and that users are able to perform tasks with less training or practice [HGSG15]. Our previous research also indicates that users perceive artificially intelligent characters differently in VR [HHACT15].

Procedural animation systems also have the potential to produce organic motion far beyond traditional data-driven animation. With sufficient complexity, such systems could potentially synthesise life-like character motion and behaviour.

One of the key challenges with procedural animation is that as systems become more complex, so do the number of parameters and therefore permutations to consider. Furthermore, parameters are often inter-dependant and combine to invoke emergent behaviour. Automation of optimisation is also difficult, as the resultant behaviour can often be very subjective.

In this paper, we describe our research in developing techniques for optimising complex animation systems for VR. We start by describing a dolphin animation system and how we use crowd-sourcing and genetic algorithms to search the parameter space for realistic behaviour. We then explain some key differences we found between dolphins optimised using a desktop monitor and ones optimised in VR. Finally, we describe our current work which aims to further enhance the speed and intuitiveness of animation optimisation in VR.

2. Crowd-sourced Animation Optimisation

Our dolphin animation system consists of 33 parameters that control every aspect of the creature's motion and behaviour, from its speed and acceleration, to its swimming style, target selection, chattering and personality traits like barrel roll frequency, friendliness and faithfulness. These parameters combine to synthesise motion

Figure 1: *Screenshot from application showing two dolphins swimming near player with oculus touch hands.*

using a combination of steering behaviours for global translation [Rey99], and algorithmic procedural rotations of backbone and appendage joints. This parameter space allows for a vast amount of potential motions and movements, and is archetypal of reasonably complex animation systems from industry.

Some parameters have a natural optimal range (such as swim speed and acceleration), while others require an individual's own judgement (such as faithfulness and friendliness, which control how often and for how long dolphins take an interest in the user). Parameters also have varying levels of granularity. For example, *defaultSpeed* has a range from 0.0–5.0 with a granularity of 0.01 while *barrelRollChance* has a range from 100–1500 with a granularity of 1. Across the 33 parameters, there are around 3.676e101E possible dolphins.

2.1. Dolphin Optimisation Study

We conducted a study with two aims, firstly to see how crowd-sourcing could be used to optimise our complex animation system, and secondly to compare the resultant dolphins between desktop monitor and VR.

At the start of the optimisation process, a first generation of 100 dolphins were randomly generated. Users were asked to rate random dolphins from this population on a 0-5 scale based on how realistic they appeared. Each user was allowed to rate as many dolphins as they liked over a 5 minute period, and the task was repeated

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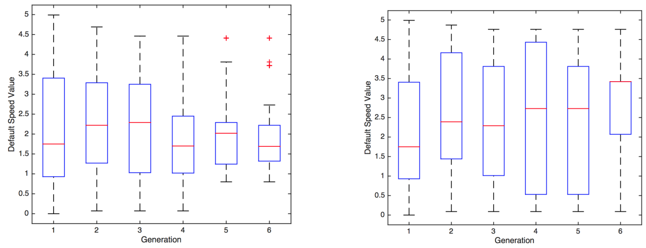

(a) *Desktop* **(b)** *VR*

Figure 2: *Value of default speed parameter over the generations.*

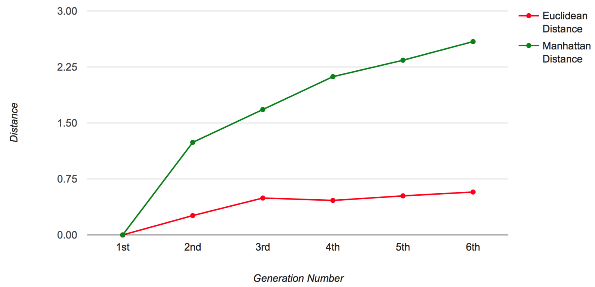

Figure 3: *Euclidean and Manhattan distances at each generation.*

for a separate but identical starting population across both VR and desktop monitor in random order.

After 100 ratings, our system used a genetic algorithm with roulette wheel selection to generate the next generation. Two children were created from each set of the top 20 parents using a single point crossover method, with each parameter given a small chance of mutating. The entire process was invisible to the end user, and some would start off rating one generation only to finish rating the next generation. In total, over 1200 dolphins were rated across six generations.

2.2. Parameter Space Divergence

By comparing the divergence between first and last generations, and between VR and desktop dolphin populations, we are able to establish some key differences in preference between parameter spaces based on viewing medium. For example, the *defaultSpeed* parameter represents the minimum speed a dolphin can swim in meters per second. As shown in Figure 2, users on average preferred faster dolphins in VR than on the desktop. Similar results were found with other parameters; users preferred dolphins that barrel rolled less often and more chattier dolphins in VR. The former could potentially be due to the increased immersion offered by 3D headtracked audio.

While some parameters can be analysed in isolation, most parameters in the system work in conjunction with others and analysing individual parameters will not give a good representation of how the average dolphin changes over the generations. However, we can compare the parameter space as a whole by calculating the Euclidean and Manhattan Distances for each generation. As shown in Figure 3, the parameter space for the desktop and VR dolphins diverge quite rapidly over the course of the study.

3. Optimisation in VR

Our results indicate that there is a significant difference in animation and behavioural preference between VR and desktop mediums. This has motivated us to consider interfaces that could further enhance animation optimisation in and for VR.

Our system as described allows for multiple users to tweak a parameter system in parallel, either locally or over the internet. However, while crowd-sourcing like this is powerful, one of the key weaknesses is that it can require a large number of users in order to achieve desired results. We are currently exploring techniques for speeding up this process by modifying the behaviour of our underling evolutionary algorithms, and the granularity of the rating system. Our overall aim is to allow a single user or small group of developers to enter VR and tune a virtual creature's behaviour in a single session.

Key to achieving this goal is to consider ways of speeding up the process of intelligently searching a potentially vast parameter space. One approach we are currently researching is the ability to lock individual or sets of parameters, in order to either temporarily concentrate on a parameter sub-space or to mark certain parameters as optimal. This could also allow users to split the optimisation task into a series of smaller parameter spaces.

The Oculus Touch motion controllers facilitate *"hand presence"*, allowing users to see their hands in VR and perform gestures like pointing, waving and thumb motions. In our initial system as described, users simply selected ratings using arrow keys or a remote control, and had no other control over the optimisation process. With our VR system, we are also extending our application to support Oculus Touch, allowing users to interact using context sensitive menus and natural hand gestures.

Our current prototype allows users to select a dolphin using a pointing gesture, which causes them to swim up to the camera for closer inspection. With a dolphin selected, users can then bring up an interactive menu and isolate parameters or tweak parameters using physical sliders. We are also exploring techniques of using other natural gestures like waving to dismiss and a "thumbs up" or "thumbs down" gesture to rate or reject candidate dolphins.

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