Sound Design for Exergames

A design research pilot project

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In a Nutshell…

Exergames profit from bodily action sounds. How can these action sounds be designed in order to enhance flow, motivation and self-competence in heterogeneous player groups?

Mainstream film & game sound define our listening expectations and interpretation and provide a huge collection of sound design "success cases". How can successful mainstream sound design patterns be used as basis for adaptive action feedback sound design?

To answer these questions, we combine qualitative interpretation, signal analytics, and sound-design expertise in a "research through design" mixed-methodology.

Background and Motivation

Exergames (exercise-oriented videogames) are becoming more popular and effective.
Besides visual and narrative game design, the sound design of exergames is particularly important:

- Sound is an efficient means to increase **motivation, immersion and performance** e.g., in sports training or in the case of exercise with chronic pain.
- Sound can be used to **manipulate perception of one's body**, e.g., arm length, perceived body size, gender and strength.
- Sound can **support movement pattern learning, guide and motivate movement execution and support movement anticipation** in various sport disciplines such as swimming, rowing, ice skating, basketball or skateboarding.

The design and research pilot project **"Sound Design for Exergames"** explores how sound design can be used to convey information about movements and to support engagement and motivation in an exergame using the "ExerCube" by Sphery. The project addresses interpretational, affective, motivational, and hedonistic aspects of sound design and perception. A particular focus lies on inclusion, with the aim to provide people with various bodily abilities to experience their actions in an equally empowering and motivating way.

The project is a joint effort by the ZHdK departments of music (ICST, MA Sound Design) and design (Game Design), the ZHAW Institute of Physiotherapy and the University of Waterloo with the support of Sphery AG (www.sphery.ch).

The Exercube

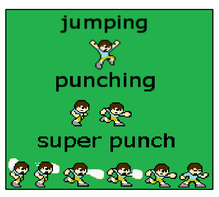
The ExerCube combines fitness training with single and multiplayer games in a three-dimensional, physically immersive cube.

Based on the physical and cognitive performance, the intensity and complexity are individually adapted in real time to match the user's needs.

The Pilot Project

We conducted a mixed methods research and design pilot project which focused on understanding the sounds of punching and jumping actions and the possibility of deriving design heuristics for the sound design of exergames.
The pilot project consisted of several related studies addressing the following questions:

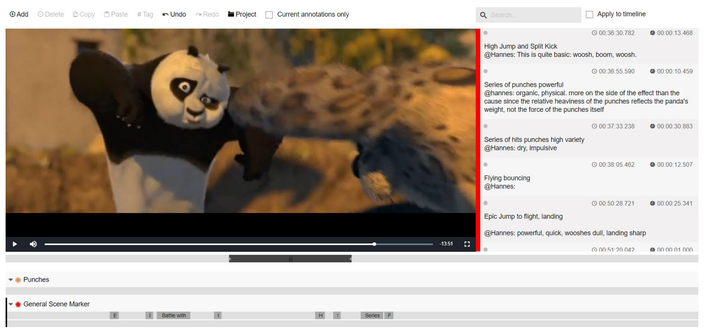
- How can we build a representative, yet manageable corpus of sounds associated with punching and jumping?
- What can be learned from these sounds and their relation to jumping and punching…
  - … using an interpretative, grounded theory informed analysis?
  - … using audio signal analysis / MIR techniques and perceptual evaluation?
  - … by trying to re-create them from scratch?
- What can we learn from experts (sports, martial arts) about experience and execution of jumps and punches?
- How can we build systematic sound design guidelines for creating new jump and punching sounds?



Each of these was addressed in a dedicated study, as described below. The studies were conducted in parallel and in an explorative manner to provide the basis for devising a coherent mixed-method approach.

Clip Acquisition and Analysis

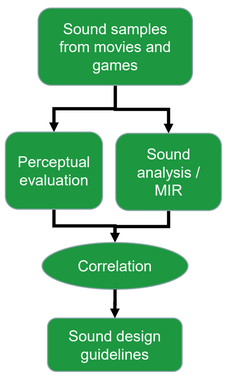
An inductive, interpretive analysis of punch and jumping sounds in three movies and one video game was conducted. The preliminary analysis helped to reveal important questions related to the extraction of clips from a large corpus of films and games, and the impact of the narrative or the visuals on interpretation. Also, a tentative list of categories for deductive coding was derived.



Audio Signal Analysis, MIR

Various audio analysis and MIR (music information retrieval) techniques were tested on the material with the aim to extract signal-level features. These can be correlated with perceptual features evaluated by means of user surveys.

Example: The perceived power of punches and jumps may be mainly related to the distribution of energy in the frequency spectrum: strong actions may be reflected by full spectra and marked brightness, whereas muffled or thin sounds are used for softer actions.



Experience and Execution of Punches and Jumps in Sports

Semi-structured interviews with three movement and sport experts covering dance, basketball, boxing, and eastern martial arts were conducted. Questions addressed elements of the movement and perception and experience of its execution.

Rating of Perceived Power

19 film clips and 15 game clips were used for a preliminary rating experiment. Participants were members of the project team (N=7). The participants were asked to rate the perceived power and provide a comment about what motivated their rating, focusing manly on sound.

Standard deviation was used to estimate the level of agreement and clips with higher level of agreement will be used for further design steps.

Rating of perceived power

(1=very low, 3 = medium, 5= very high)

	MOVIES	MEAN	MED	STDV	
1	Big_Hero_6_01	2.71	3	1.38	P
2	Big_Hero_6_02	4.29	4	0.76	P
3	Big_Hero_6_05	2.71	2	1.11	P
4	Big_Hero_6_11	3.00	3	0.58	P
5	kung_fu_hustle_scene_1_01	3.43	3	0.53	J
6	kung_fu_hustle_scene_1_03	3.00	3	1.15	J
7	kung_fu_hustle_scene_1_04	3.14	3	0.90	P
8	kung_fu_hustle_scene_1_05	3.57	4	1.40	P
9	kung_fu_hustle_scene_1_06	3.71	4	0.76	P
10	kung_fu_hustle_scene_1_08	4.71	5	0.49	P
11	kung_fu_hustle_scene_1_09	3.29	3	0.76	P
12	raging_bull_pt2_03 (only first h	2.43	2	0.79	P
13	raging_bull_pt2_04 (only first h	3.14	3	0.90	P
14	raging_bull_pt2_05	4.14	4	0.38	P
15	raging_bull_pt2_06	4.57	5	0.53	P
16	raging_bull_pt2_11	3.71	4	0.76	P
17	raging_bull_pt2_13	3.57	3	0.79	P
18	raging_bull_pt2_14	3.71	4	0.49	P
19	raging_bull_pt2_15	4.57	5	0.53	P

	GAMES	MEAN	MED	STDV	
1	spider_man_ps4_03	3.00	3	0.00	P
2	spider_man_ps4_04	4.14	4	0.69	P
3	spider_man_ps4_05	2.14	2	0.69	J
4	spider_man_ps4_06	4.43	5	0.79	J
5	god_of_war_01	2.71	3	0.95	P
6	god_of_war_02	4.14	4	0.69	P
7	god_of_war_05 (only first hit)	4.43	4	0.53	P
8	ultra_street_fighter_02	2.86	3	0.69	P
9	ultra_street_fighter_03	3.86	4	0.69	P
10	ultra_street_fighter_04 (impac	4.57	5	0.79	P
11	super_mario_odyssey_01	2.29	2	0.95	J
12	super_mario_odyssey_02	2.57	2	0.79	P
13	super_mario_odyssey_04	2.43	3	0.79	J
14	super_mario_odyssey_05 (hit	2.00	2	0.82	P
15	super_mario_odyssey_06 (sto	3.86	4	0.90	P

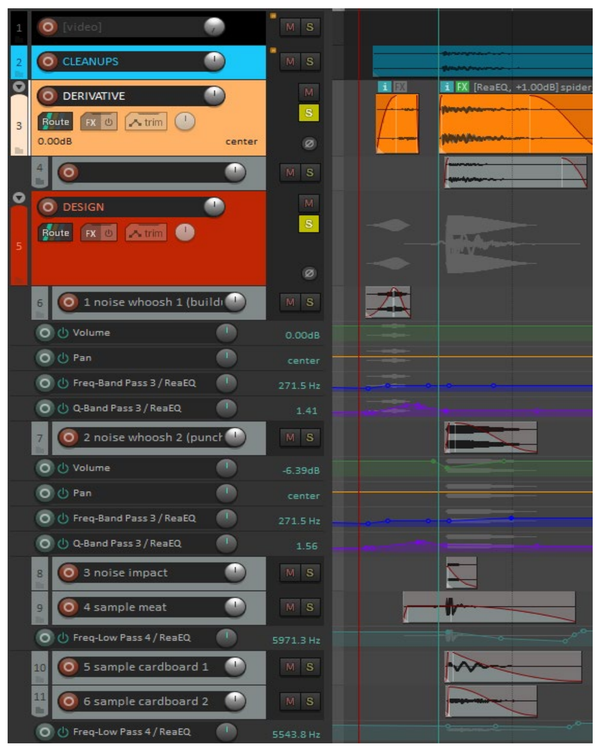
Sound Re-Design and Derivates

The aim of this study was to create a systematic and documented sonic analysis and re-design of punching and jumping sounds.

The same clips that were used in the rating experiment were cleaned manually using Izotope RX. Based on the ratings, another subset of clips was identified which would be used for the re-design interpretation (marked green in the rating table).

The sound designers were asked to carefully protocol their listening analysis and design hypothesis in terms of sonic elements and how the sound could be re-composed. This involved a discussion of what would be the central non-reducible elements of the sounds. Then the sounds would be re-designed, combining various sound elements to provide a modular "compositional toolbox" for sound design derivates.

Currently sound designers are creating "weak", a "normal" and a "powerful" versions of sounds based on reference clips. These sounds will be used as stimuli in passive and active listening tests.



Screenshot of Sound Design Re-Composition by Jan Godde

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