



Universität des Saarlandes
Deutsches Forschungszentrum
für Künstliche Intelligenz



ImMotion

An Exergame for Warm Up Guidance

Masterarbeit im Fach Informatik
Master's Thesis in Computer Science
von / by

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angefertigt unter der Leitung von / supervised by
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begutachtet von / reviewers
Prof. Dr. Antonio Krüger

Saarbrücken, Saturday 25th August, 2018

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Ich erkläre hiermit an Eides Statt, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel verwendet habe.

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Marko Vujić

Abstract

Past research related to exergames has found that they can help in motivating people to exercise by converting physical activity into an enjoyable game. However, these exergames have been single purpose usually home fitness only. In this thesis, we designed an exergame for warm up guidance to be used in gyms and fitness centres before physically more strenuous exercise. We utilised immersive technologies based on the hypothesis that they can be used as a guiding tool for warm up procedures, would increase warm up duration, and increase exercise enjoyment. In order to evaluate our exergame we have conducted two user studies. The first was an online study where we collected responses from 466 participants about their work out and warm up habits. For the second study we followed a between subject design with 10 participants and two conditions: (a) warming up by following a video with a fitness instructor guiding through a warm up session; (b) warming up by interacting with our exergame solution. The results from the exergame condition showed a statistically significant difference in exercise duration, enjoyment of the physical activity, and participants' momentary feeling of pleasure relative to the non-gaming condition. In summary, the experiment results and survey responses suggest that the our exergame can effectively guide amateur athletes through a general warm up procedure by utilising immersive technologies and an appealing game design.

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Appendices

Prof. Dr. Jürgen Steimle
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Saarbrücken, 14.03.2018

**Statement of the Ethical Review Board (ERB)
in response to your application (No. 18-2-3)**

Dear Mr. Vujic,

the ERB has reviewed your research project “Warm Up Exergame”. According to its regulations, approved by the Department of Computer Science of Saarland University on October 26, 2016, the ERB has come to the following conclusion:

“There are no ethical concerns against the implementation of the research project, if requirements to be determined are fulfilled”

Given sensitive personal information about the health status of the participants is going to be collected, it is absolutely mandatory that this data is stored and processed anonymously. It is also mandatory that the experimenter and all researchers who work with the data are familiar with and follow the regulations regarding data protection.

If you have any questions, please let me know. We wish you all the best in your future research endeavours.

Best regards, on behalf of the ERB



Prof. Dr. Jürgen Steimle
Member of the Ethical Review Board
of the Department of Computer Sciences at Saarland University

Do you often skip warm up before workout?



Take part in our study!

If you do some sport and find warm up boring, we are looking for you!

Each participant will perform a warm up session, just this time, it will be more fun!

What do you need to do?

What do you get for that?

The study will be conducted on March 28th and 29th, 2018.

Number of participants limited!
Sign up now!

- We guide you through one warm up session
- We measure your range of motion and heart rate
- You fill in few questionnaires

- **10 € Cash**
- Opportunity to try a new way of warming up



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Study 'Exergame'
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Do you often skip warm up before workout?



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Each participant will perform a warm up session, just this time, it will be fun to do it!

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The study will be conducted on March 28th and 29th, 2018.

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Study 'Exergame'
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Pre-study Questionnaire

The questions in this questionnaire are related to participant's demographics, exercise and warm up preferences, and previous game and exergame experience.

*Required

General questions.

This section covers some general questions.

1. What is your gender? *

Mark only one oval.

- Female
- Male

2. What is your age? *

3. What is the highest level of education you have completed? *

Mark only one oval.

- No schooling completed
- High school diploma
- Associate degree
- Bachelor's degree
- Master's degree
- Professional degree
- Doctorate degree
- Other: _____

Warm up related questions.

This section covers some general, sports and warm up related questions.

4. How often do you participate in sports and physical activity per week? *

Mark only one oval.

- 0 (irregularly, sometimes less than once per week)
- 1-2 per week
- 3-4 per week
- 5-6 per week
- 7-8 per week
- More

5. What kind of exercise do you normally do?*Tick all that apply.*

- Yoga
- Play sports
- Jogging
- Swimming
- Running
- Cycling
- Dancing
- Ice-skating
- Treadmills
- Anaerobic exercise, such as sit-ups, pull-ups and push-ups, squats and weight lifting
- Other: _____

6. How many hours does your sport session (training) last? **Mark only one oval.*

- Less than an hour
- 1 - 2 hours
- More than 2 hours
- More than 3 hours
- More than 4 hours (multiple training sessions)
- Other: _____

7. Most of the time, do you exercise... **Mark only one oval.*

- alone?
- with a friend (or friends)?
- in a group?

8. Do you always warm up before the exercise? **Mark only one oval.*

- Yes, I always warm up before the exercise. *Skip to question 10.*
- No, I do not always warm up before the exercise. *Skip to question 9.*

9. If you skip warm up exercises, what are the reasons for doing so? **Tick all that apply.*

- I don't have time for it
 It is a boring activity so I tend to skip it
 I don't think it is important
 I don't know how to warm up
 I don't feel comfortable warming up if other people are present
 No one warms up around me so I skip it too
 Other: _____

Questions related to your warm up preferences.**10. ****Mark only one oval per row.*

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Warm up before exercise is important for me	<input type="radio"/>				
After my warm up routine, I feel I am prepared for the physically more demanding activity	<input type="radio"/>				
Warm up before exercise can positively affect my performance	<input type="radio"/>				
Warm up before exercise can reduce the likelihood of an injury	<input type="radio"/>				

11. Do you follow some recommended warm up procedure? **Mark only one oval.*

- Yes
 No *Skip to question 12.*

Questions related to warm up preferences.**12. When you warm up, how long does your warm up usually last? ****Mark only one oval.*

- Less than 1 minute
 Less than 5 minutes
 Between 5 and 10 minutes
 Between 10 and 15 minutes
 More than 15 minutes

13. What kind of warm up routine do you perform before sports activity? **Mark only one oval.*

- General (non specific) warm up
- Sport specific warm up (warm up reflects the type of movements and actions which will be required during the sporting event)
- Passive warm up (e.g., taking a hot shower, having a rubdown, sitting in the sun)

14. Do you prefer warming up in a group? **Mark only one oval.*

- Yes
- No

15. Do you prefer warming up when you are given instructions? **Mark only one oval.*

- Yes
- No

Game Related Questions

16. How often (on average) do you play video games ?*Mark only one oval.*

- Daily
- Few times per week
- Once per week
- Few times per month
- Once per month
- Few times per year
- Once per year or less

17. What are your favorite game genres?*Tick all that apply.* First-Person Shooters Third-Person Shooters Fighting Real-time Strategy Turn-based Strategy Role-playing games Adventure games Action-adventures Racing games Sports Simulation Party games Music games Casual games Puzzle games Digital board games Serious games Other: _____**18. Rate your previous experience with the Microsoft Kinect games.***Mark only one oval.*

1 2 3 4 5

No prior experience with
it

I have a lot of experience with it

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Physical Activity Readiness Questionnaire (PAR-Q) and You

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly:

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of <u>any other reason</u> why you should not do physical activity?

If you answered:	YES to one or more questions
	Talk to your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES. <ul style="list-style-type: none">• You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.• Find out which community programs are safe and helpful for you.
NO to all questions	Delay becoming much more active: <ul style="list-style-type: none">• If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or• If you are or may be pregnant – talk to your doctor before you start becoming more active. <p>Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.</p>

Physical Activity, Exercise, and Sport Questionnaire (Bewegungs- und Sportaktivitaet Fragebogen; BSA-Fragebogen or BSA-F)

BSA-Fragebogen

1	Sind Sie berufstätig (auch Hausfrau/-mann) oder in Ausbildung?			
	<input type="checkbox"/> ja	⇒ weiter mit Frage 2	<input type="checkbox"/> nein	⇒ weiter mit Frage 3

2	Ihre Berufstätigkeit bzw. Ausbildung umfasst ...				
sitzende Tätigkeiten	<input type="checkbox"/> keine	<input type="checkbox"/> eher wenig etwas	<input type="checkbox"/> eher mehr	<input type="checkbox"/> viel	
mäßige Bewegung	<input type="checkbox"/> keine	<input type="checkbox"/> eher wenig	<input type="checkbox"/> eher mehr	<input type="checkbox"/> viel	
intensive Bewegung	<input type="checkbox"/> keine	<input type="checkbox"/> eher wenig	<input type="checkbox"/> eher mehr	<input type="checkbox"/> viel	

3	An wie vielen Tagen und wie lange haben Sie die folgenden Aktivitäten in den letzten 4 Wochen ausgeübt?			
Zu Fuß zur Arbeit gehen (auch längere Teilstrecken)	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Zu Fuß zum Einkaufen gehen	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Radfahren zur Arbeit	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Radfahren zu sonstigen Fortbewegungs-zwecken	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Spazierengehen	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Gartenarbeit (z. B. Rasen mähen, Hecke schneiden)	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Körperlich anstrengende Hausarbeit (z. B. Putzen, Aufräumen)	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>
Körperlich anstrengende Pflegearbeit (z. B. Kinder betreuen, Kranke pflegen)	an Tagen während der 4 Wochen	ca. Minuten pro Tag	nicht gemacht	<input type="checkbox"/>

4	An wie vielen Tagen und wie lange haben Sie die folgenden Aktivitäten in den letzten 4 Wochen ausgeübt?			
Treppensteigen	an Tagen während der 4 Wochen	ca. Stockwerke pro Tag	nicht gemacht	<input type="checkbox"/>

5	Haben Sie in den letzten 4 Wochen regelmäßige sportliche Aktivität betrieben?			
	<input type="checkbox"/> ja	⇒ weiter mit Frage 6	<input type="checkbox"/> nein	⇒ weiter mit Frage xy

6	Um welche sportliche(n) Aktivität(en) handelt es sich dabei?		
	A (bitte hier eintragen)	B (bitte hier eintragen)	C (bitte hier eintragen)
	Aktivität A habe ich in den letzten 4 Wochen ca. Mal ausgeübt, und zwar bei jedem Mal für ca. Minuten	Aktivität B habe ich in den letzten 4 Wochen ca. Mal ausgeübt, und zwar bei jedem Mal für ca. Minuten	Aktivität C habe ich in den letzten 4 Wochen ca. Mal ausgeübt, und zwar bei jedem Mal für ca. Minuten

Physical Activity Enjoyment Scale (PACES)

#	Item
1	I enjoy it; I hate it
2	I feel bored; I feel interested
3	I dislike it; I like it
4	I find it pleasurable; I find it unpleasurable
5	I am very absorbed in this activity; I am not at all absorbed in this activity
6	It's no fun at all; It's a lot of fun
7	I find it energizing; I find it tiring
8	It makes me depressed; It makes me happy
9	It's very pleasant; It's very unpleasant
10	I feel good physically while doing it; I feel bad physically while doing it
11	It's very invigorating; It's not at all invigorating
12	I am very frustrated by it; I am not at all frustrated by it
13	It's very gratifying; It's not at all gratifying
14	It's very exhilarating; It's not at all exhilarating
15	It's not at all stimulating; It's very stimulating
16	It gives me a strong sense of accomplishment; It does not give me any sense of accomplishment
17	It's very refreshing; It's not at all refreshing
18	I felt as though I would rather be doing something else; I felt as though there was nothing else I

BORG RATING OF PERCEIVED EXERTION (RPE)

While performing the warm up activity, we would like you to rate your perceived perception of exertion. This feeling reflects how difficult and strenuous the performed warm up exercise feels to you, combining all sensations and feelings of physical stress, effort, and fatigue. While you rate your perceived exertion, please do not concern yourself with factors such as leg pain or shortness of breath, but try to focus on your overall feeling of exertion.

Please look at the rating scale below and select a number that best describes your level of exertion.¹ The scale ranges from 6 to 20, where 6 means "*no exertion at all*" and 20 means "*maximal exertion*". Choose the number from below that best describes your level of exertion. Value 9 corresponds to "*very light*" exercise. For a healthy person, it is like walking slowly at his or her own pace for some minutes. Value 13 on the scale is "*somewhat hard*" exercise, but it still feels OK to continue. Value 17 is "*very hard*" and corresponds to very strenuous exercise. A healthy person can still go on, but he or she really has to push him- or herself. It feels very heavy, and the person is very tired. Value 19 on the scale is an extremely strenuous exercise level. For most people this is the most strenuous exercise they have ever experienced.

¹ <https://www.cdc.gov/physicalactivity/basics/measuring/exertion.htm>

#	Level of Exertion
6	No exertion at all
7	
7.5	Extremely light (7.5)
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Participant ID: _____

Site: _____

Date: ____/____/____

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the website *today*.

	Strongly Disagree				Strongly Agree
1. I think that I would like to use this website frequently.	<input type="checkbox"/>				
2. I found this website unnecessarily complex.	<input type="checkbox"/>				
3. I thought this website was easy to use.	<input type="checkbox"/>				
4. I think that I would need assistance to be able to use this website.	<input type="checkbox"/>				
5. I found the various functions in this website were well integrated.	<input type="checkbox"/>				
6. I thought there was too much inconsistency in this website.	<input type="checkbox"/>				
7. I would imagine that most people would learn to use this website very quickly.	<input type="checkbox"/>				
8. I found this website very cumbersome/awkward to use.	<input type="checkbox"/>				
9. I felt very confident using this website.	<input type="checkbox"/>				
10. I needed to learn a lot of things before I could get going with this website.	<input type="checkbox"/>				

Please provide any comments about this website:

Post-study Exergame Group Questionnaire

1. Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Using the exergame is a fun way to warm up.	<input type="radio"/>				
Using the exergame is an exciting way to warm up.	<input type="radio"/>				
The exergame is challenging to play.	<input type="radio"/>				
The exergame is frustrating to play.	<input type="radio"/>				
The exergame is easy to learn to play.	<input type="radio"/>				
The exergame is boring to play.	<input type="radio"/>				

2. Mark only one oval per row.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I liked the avatar design.	<input type="radio"/>				
The in-game (live) scoreboard motivated me to play longer.	<input type="radio"/>				
The possibility to collect more coins motivated me to move more.	<input type="radio"/>				
I did not care if hit by an obstacle.	<input type="radio"/>				
The exercise movements induced by coins and obstacles felt intuitive and came naturally.	<input type="radio"/>				

3. I would consider using the exergames in order to warm up before physically more demanding exercise.

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

4. Which features did you like the most?

5. Which features did you dislike the most?

6. How would you improve the exergame?

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Post-study Video Group Questionnaire

1. *Mark only one oval per row.*

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Using the warm up video is a fun way to warm up.	<input type="radio"/>				
Using the warm up video is an exciting way to warm up.	<input type="radio"/>				
The video warm up is challenging to play.	<input type="radio"/>				
The video warm up is frustrating to play.	<input type="radio"/>				
The video warm up is easy to follow.	<input type="radio"/>				
The video warm up is boring to play.	<input type="radio"/>				

2. **I would consider using the warm up video in order to warm up before physically more demanding exercise.**

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

Post-study-Exp