Technische Universiteit Eindhoven University of Technology

Form 1: Request for permission to take a doctor's degree and proposal for Doctorate Committee
Send this form not later than 6 months before the desired defense date to the Office of Doctoral Presentations and Academic Ceremonies, per internal post: MF 3.075. For a digital form: www.tue.nl/promoties

The doctoral candidate	
Gender	☐ F ☒ M Citizen Service Number: 283187074
Academic titles	☐ ir. ☐ drs. ☒ MSc ☐ other:
Full first names	Gabriele
Last name	Spina
Date, place and country of birth	22/10/1986, Palermo, Italy
TU/e internal address and/or full external postal address	Department of Electrical Engineering Signal Processing Systems, FLX 7.060 Technische Universiteit Eindhoven Eindhoven 5600 MB , The Netherlands
Telephone number(s) TU/e internal / external / mobile	+31 628 460 517
E-mail address(es)	g.spina@tue.nl gabriele.spina@philips.com
	and the supervisors state that the doctoral candidate has successfully ☐ **completed the Dutch (Master) program below** ☒ **followed the non-Dutch program below and has obtained exemption from the program requirement**
Date on diploma	27/05/2011
Date on exemption letter (in case of a non-Dutch diploma)	06/03/2012
Name study	Biomedical Engineering
Name university	Campus Bio-Medico University of Rome
City and country	Rome, Italy
	and ask the Doctorate Board for ☒ **admission to the defense ceremony** ☐ **admission to the double doctorate** ☐ **admission to the joint doctorate**
State name partner university in case of a double doctorate	
	of the ☒dissertation ☐technological design entitled:
	Training and monitoring methodologies for chronic obstructive pulmonary disease patients in daily life.
	and propose a Doctorate Committee in conformity with the Regulations governing the conferral of doctor's degrees, with the names and addresses of the members described on the following page

		I ☐	II ☐	III ☐	IV ☐	To be completed by the doctoral candidate and supervisor(s): I = A + C + E + F + G + H II = A + C + D + E + F + G III = A + B + E + F + G + H IV = A + B + C + E + F + G
A, B	Supervisor(s)	1	1	2	2	
C, D	Co-supervisor(s)	1	2	0	1	
E, F	External members	2	2	2	2	

See p.4

G, H	Other members (optional) including advisers	2	1	2	1	
I	Member TU/e	1	1	1	1	To be completed by the dean: I thru IV = I + J
J	Chairman	1	1	1	1	
	Max. number members	8	8	8	8	

To be completed according to the structure of the Doctorate Committee on previous page (I, II, III or IV)

1st supervisor	**A**
Titles, initials and last name	Prof. dr. R.M. Aarts
Position, affiliation, postal address	☐ full-time professor ☒ part-time professor ☐ emeritus per: Department of Electrical Engineering, Signal Processing Systems group, FLX 7.104 Technische Universiteit Eindhoven P.O. Box 513 5600 MB Eindhoven, the Netherlands
Email address	ronald.m.aarts@philips.com
2nd supervisor	**B**
Titles, initials and last name	Prof. E.F.M. Wouters
Position, affiliation, postal address	☒ full-time professor ☐ part-time professor ☐ emeritus per: Department of Respiratory Medicine, Maastricht University Medical Centre, Minderbroedersberg 4-6 6211 LK Maastricht, The Netherlands
Email address	e.wouters@mumc.nl
Co-supervisor 1	**C**
Titles, initials and last name	Dr. Albertus C. den Brinker
Position, affiliation, postal address	☐ assistant professor ☐ associate professor ☒ otherwise: Principal Research Scientist Philips Research High Tech Campus HTC-34 1.041 5656 AE Eindhoven, The Netherlands
Email address	bert.den.brinker@philips.com
Co-supervisor 2	**D**
Titles, initials and last name	Dr. Martijn A. Spruit
Position, affiliation, postal address	☐ assistant professor ☒ associate professor ☐ otherwise: Associate Professor Rehabilitation Sciences Hasselt University and Scientific advisor at CIRO+, 6085 NM Horn, The Netherlands
Email address	martijnspruit@ciro-horn.nl
External member 1	**E**
Titles, initials and last name	prof.dr.ir. P.F.F. Wijn
Position, affiliation, postal address (or TU/e internal address)	☒ professor ☐ associate professor ☐ expert** ☐ emeritus per: Department of Applied Physics School of Medical Physics and Engineering Eindhoven FLX 0.111 Technische Universiteit Eindhoven P.O. Box 513 5600 MB Eindhoven, the Netherlands
Email address	p.f.f.wijn@tue.nl
External member 2	**F**
Titles, initials and last name	dr.ir. T.J. Tjalkens
Position, affiliation, postal address (or TU/e internal address)	☐ professor ☒ associate professor ☐ expert** ☐ emeritus per: Department of Electrical Engineering Signal Processing Systems FLX 7.101 Technische Universiteit Eindhoven P.O. Box 513 5600 MB Eindhoven, The Netherlands
Email address	t.j.tjalkens@tue.nl

TU/e Technische Universiteit Eindhoven University of Technology

Other member 1 / adviser*	G
Titles, initials and last name	Dr. ir. Pierluigi Casale
Position, affiliation, postal address (or TU/e internal address)	☐ professor ☐ associate prof. ☐ assistant prof. ☒ expert** ☐ emeritus per: ☐ otherwise: Data Scientist Wearable Healthcare IMEC/Holst Center 5656 AE Eindhoven The Netherlands
Email address	Pierluigi.Casale@imec-nl.nl
Other member 2 / adviser*	**H**
Titles, initials and last name	
Position, affiliation, postal address (or TU/e internal address)	☐ professor ☐ associate prof. ☐ assistant prof. ☐ expert** ☐ emeritus per: ☐ otherwise:
Email address	

* Delete as appropriate
** In case of an expert, please add to this form:
reason stated request from the supervisor, the CV and the list of publications of the relevant person. There is only 1 expert allowed per committee.

All proposed members have indicated their willingness to sit on the Doctorate Committee	
R.M. Aarts June 13 2015 Date, name and signature 1st supervisor	Efm Wouters Date, name and signature 2nd supervisor
13/07/2015 Gabriele Spina Date, name and signature doctoral candidate	

To be completed by the dean

Member TU/e	I
Position, titles, initials, last name	☐ full-time associate professor ☐ full-time professor (no part time or emeritus)
Postal address or TU/e internal address	
Email address	
Chairman (in first the dean)	**J**
Titles, initials and last name	
Postal address or TU/e internal address	
Email address	
Reserve member (preferably TU/e i.c.w. easy accessibility)	
Titles, initials and last name	☐ professor ☐ associate professor
Postal address or TU/e internal address	

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Email address	
Positive recommendation from the dean	
Date, name and signature dean ☐ B ☐ BMT ☐ EE ☐ IE&IS ☐ ID ☐ ST ☐ TN ☐ W ☐ W&I ☐ ESoE	

Appendices to form 1, initials dean for seen and approved	**Dean**
☐ Original Dutch diploma (show to dean). ☐ Certified copy of the Dutch diploma. ☐ Copy of the letter "ontheffing vooropleidingseis" (exemption program requirement).	
☐ 1 A-4 English description of the research (dean, please also initial English description).	
☐ CV and list of publications of the doctoral candidate.	
☐ It concerns a double doctorate and the agreement has been appended to this form.	
☐ An expert is proposed and the dean has indicated on the request that he supports the proposal (dean, please also initial the request).	

Dear Dean and P&P,

Please note that in the present Form 1 (at the end of pag.1) it is requested to state which is the structure of the Doctorate Committee. The option 2 promoters + 2 co-promoters is not present. However, I like to deviate from the usual possible committee structure options I-IV, because this project is having many stakeholders and involved experts (TU/e, CIRO, Univ. Maastricht, Hasselt University, and Philips), which seems to be fair that all have an appropriate role in the committee. I sincerely hope that you will agree with this.

Prof.dr. Ronald M. Aarts

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Initials dean for seen:

	English description of the doctoral research, the methods used thereby and results deemed relevant
Name doctoral candidate	
Title dissertation / technological design	**Training and monitoring methodologies for chronic obstructive pulmonary disease patients in daily life.**

This thesis aims to investigate the feasibility of using unobtrusive technologies in order to provide useful and modular patient training and monitoring methodologies. The research focuses in particular on COPD patients with data comprising physiological information and physical activity. Signal processing and machine learning methods are investigated and further developed to construct reliable algorithms to derive COPD relevant indicators and trends including patient characteristics and behavioral patterns. The extracted information can be used to obtain objective behavioral assessment and new markers of patient's improvements under free living conditions. In particular the following results are achieved.

A new framework has been proposed and evaluated for smartphone-based sensor data recording and processing. Since extensibility is a key feature, it has been implemented in a layered framework design. This was evaluated to show its versatility to handle various multi-modal sensors and recognition solutions, which are essential elements when prototyping patient care solutions on phones.

A novel exercise training and feedback system has been developed using smartphone-integrated sensors only. The proposed approach integrates well into therapy routines, where an initial training session with a therapist is used to derive exercise quality parameters. In subsequent patient training sessions, the system can provide instant acoustic feedback on the detected exercise performance. The validation with healthy participants showed an overall accuracy of 96.2% in recognizing exercise performances. The intervention study with 7 COPD patients showed a 96.7% accuracy in exercise repetitions counts and a 87.5% accuracy in recognizing exercise performances.

Detailed analyses of physical activity (PA) measures in COPD have been conducted on data COPD patients and healthy matching control subjects. The results show that compared with healthy subjects, COPD patients spent not only less time in higher intensities of physical activity (PA), but also more time in lower intensities. Interestingly, patients with COPD spent more time in very light intensity than healthy subjects, but there is no difference for the time in light intensity. In general, healthy subjects perform their activities at higher intensities compared to patients with COPD, and this difference is more pronounced during weekdays. Reducing the time in very light intensity without necessarily increasing the time in moderate-to-vigorous intensity may be an important strategy for achieving health benefits in patients with COPD. Moreover 5 subgroups of patients were identified each with distinct PA measures and PA hourly temporal trends, which can be useful to tailor interventions according to the needs of each group. Results show that outcome measures need to be clearly delineated when evaluating interventions aiming to promote PA in patients with COPD.

Using relatively simple assumptions and settings, it has been shown that interpretable and consistent results can be obtained from a large set of unannotated real-life data concerning a large population of COPD and healthy subjects. Physical activity (PA) routines patterns integrate and represent daily PA measures and physiological responses. The discovered PA routines were found suitable to label, in an unsupervised way, subjects and assessed days and could be valid constructs to quantify PA behavioral change in patient with limited exercise capacity. In particular, PA routines in COPD patients and healthy subjects are considerably different regarding their composition and they show certain consistent trends reflecting the stage of the disease as measured by common clinical practice.

Disturbed sleep could play a substantial role in daytime symptoms and chronic fatigue commonly found in COPD patients. Objectively measured sleep characteristics were identified in patients and compared to the ones assessed in healthy subjects. Sleep is further analyzed by using topic modelling techniques to investigate pattern of sleep from multimodal sensor data. In addition the effects of disturbed sleep on daytime function is investigated and reported.

The continuous monitoring of respiratory and cardiac variables may be relevant to provide further insights into the role of dynamic hyperinflation in the genesis of dyspnea. Therefore a new wearable system was developed comprising of a unique, low cost, not visible and flat acoustic sensor connected to a low resources analysis system. To estimate a number of physiological variables (respiration rate, breathing phase duration and cardiac related variables) the system uses a decomposition technique on time-series of features extracted from audio signals measured at the chest. The proposed system provides a robust method to continuously monitor breathing parameters such as respiration onsets and duration of respiration phases.