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INFRARED THERMOGRAPHY IMAGING FOR CONTACTLESS NEONATAL MONITORING AND CARE

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To my son Ameen

Teile der Veröffentlichungen sind in die Dissertationsschrift eingeflossen

Contents

List of symbols and constants x

List of abbreviations xiii

Chapter 1 1

Introduction and Background 1

1.1 Overview 1
1.2 Motivation 2
1.3 Scope of the thesis 4
1.4 Thermoregulation physiology in neonates 4
1.4.1 Thermo-neutral and thermo-normal 6
1.4.2 Optimal thermal environment 9
1.4.3 Neonatal thermal balance 10
1.5 Modes of heat transfer in newborn infants 11
1.5.1 Convection heat transfer 13
1.5.2 Respiratory heat loss 17
1.5.3 Humidity 19
1.5.4 Phototherapy 21
1.5.5 Open Radiant Warmers 22
1.6 Physiological parameters monitoring 25
1.7 Neonatal temperature monitoring 26
1.8 Temperature measurement of neonate 27
1.9 Temperature sensors in neonatal incubator 30
1.9.1 Thermistor-based sensing 30
1.9.2 Thermocouples 31
1.9.3 Nasal temperature sensors 32
1.9.4 Disturbance effect in neonatal incubator temperature monitoring 33
1.10 Summary 35
Chapter 2 37

State of the Art: Infrared Thermography Imaging (IRT) 37

2.1 Overview 37
2.2 Infrared thermography imaging 39
2.2.1 Infrared thermography physical principles 39
2.2.2 Infrared radiation 39
2.2.3 Planck's equation of thermal radiation 40
2.4 Infrared thermal camera 43
2.4.1 Optical system 45
2.4.2 Thermal detectors 45
2.4.3 Scanning mechanism 49
2.4.4 Thermal signal processing 50

2.4.5 Displays....51
2.4.6 Thermography Settings and Calibration....51
2.4.7 Nonuniformity Correction (NUC)....52
2.4.8 Modulation transfer function (MTF)....54
2.4.9 Nyquist limit and aliasing....56
2.4.10 Noise equivalent temperature difference (NETD)....57
2.4.11 Field of view (FOV)....58
2.4.12 Dynamic range....59
2.5 Physiology of infrared thermal signature....60
Chapter 3....63
Experimental design and NIRT clinical setup....63
3.1 Patient population and selection criteria....63
3.2 System setup and experimental design....64
3.2.1 Convective neonatal incubator....65
3.2.2 Kangaroo mother care system....67
3.3 Infrared transparent material....70
3.4 Reference temperature and physiological parameters measurement....71
3.5 Field of View (FOV) setting....71
3.6 Infrared thermography correction....72
3.7 A method for temperature calibration....74
3.7 Compartmental analysis of heat fluxes through thermography measurement....76
3.9 NIRT correction models for different neonatal care systems....78
3.9.1 Convective NIRT correction (first sequence)....78
3.9.2 Kangaroo mother care (KMC) NIRT correction....82
3.9.3 Open radiant warmer NIRT correction....84
3.10 Room temperature setting....86
Chapter 4....87
Virtual sensing approach....87
4.1 Virtual temperature sensing concept....87
4.1.1 VTS Architecture....87
4.1.2 ROI-tracking method....88
4.1.3 Template matching technique....89
4.1.4 Parametric vector approach for template matching....91
4.1.5 Geometry definition and delineation....93
Chapter 5....96
Non-contact respiration monitoring inside neonatal intensive care unit....96
5.1 Respiration monitoring in a neonatal intensive care unit....96
5.2 Contactless approach in respiration monitoring....97
5.3 Assumption 2a....98

5.3.1 Respiration thermal signature 98
5.3.2 Modeling of infrared respiration thermal signal 100
5.4 Experimental setting 103
5.4.1 Patient population and selection criteria 105
5.4.2 Camera setting and field of view (FOV) 106
5.5 Assumption 2b 107
5.5.1 IRTR detection from nasal jet stream reflection-Indirect IR imaging 107
5.6 IRTR signal acquisition and processing 107
5.6.1 First-order statistics and correlation analysis 108
5.6.2 Wavelet analysis 110
5.7 IRTR signal Modeling and Simulation 112
5.7.1 Respiration cycle thermal signature modeling 112
Chapter 6 115
Results and Discussion 115
6.1 Overview 115
6.2 Results for NIRT imaging 115
6.2.1 Regional temperature behavior in NIRT imaging 118
6.3 Results for IRTR monitoring 121
Chapter 7 126
Conclusion and Future Work 126
7.1 Objective 1 126
7.1.1 Objective 1a: NIRT imaging during convective incubator care 126
7.1.2 Objective 1b: NIRT imaging during kangaroo mother care 126
7.2 Objective 2 126
7.2.1 Objective 2a: Contactless respiration monitoring - direct imaging 126
7.2.2 Objective 2b: Contactless respiration monitoring - indirect imaging 128
7.3. Technical limitation of NIRT imaging 129
7.4 Further development of NIRT imaging and other non-contact physiological monitoring 130
7.5 Wireless neonatal incubator 131
Bibliography 133
Appendix 151
Acknowledgement 156

List of symbols and constants

Symbol	Description	Unit
α_{calib}	Calibration coefficient	-
A_c	Nasal surface area	cm^2
A	Area of the body (surface)	cm^2
P_λ	Illuminisity monochromatic	-
P	Total illumination	cd/m^2
P_T	Translated sub-image vector	-
P_S	Scaled sub-image vector	-
dλ	Difference in wavelength	µm or nm
σ	Stefan-Boltzmann constant	$W\ m^{-2}\ K^{-4}$
ε	Emissivity	-
ε_{obj}	Emissivity of the object under test	-
ε_w	Emissivity of the window (PE)	-
ε(λ)	Spectral emissivity	Percentage or ratio
C_{bl}	Heat capacity of the blood	J/K
ξ	Blood perfusion rate	ml/min
E_{total}	Total energy of the IRTR signal	Watt
f_l	Optical focal length	cm
T	Body temperature	[°C]
c_1	First Planck's constant of material	$3.741832*10^4\ W\ cm^{-2}\mu m^4$
c_2	Second Planck's constant of material	14387.86 µm K
K	Equation constants	-
T'	Final bodytemperature	[°C]
v	Velocity	m/s
h	Planck's constant ($6.62606957 \times 10^{-34}$)	J.s
h_c	Heat convective coefficient	$W/(m^2K)$
H_{conv}	Heat exchange rate by convection	$W/(m^2K).s^{-1}$
H_{rad}	Heat exchange rate by radiation	$W/(m^2K).s^{-1}$
H_{cond}	Heat exchange rate by conduction	$W/(m^2K).s^{-1}$
H_{evap}	Heat exchange rate by evaporation	$W/(m^2K).s^{-1}$
$H_{evap\text{-}r}$	Heat exchange rate by evaporation through airway	$W/(m^2K).s^{-1}$
c	Speed of light (299 792 458)	m/s
λ	Wavelength	nm
λ_0	Section-geometric wavelength	nm
n	N-type semiconductor	-
p	P-type semiconductor	-
ρ_{bl}	Blood density (1060)	kg/m^3
c_p	Specific heat capacity	J/K
T_t	Tissue temperature	[°C]
Δ	Gradient of variables	-
k	Constant	-
T_B	Blood temperature	[°C]
T_{air}	Air temperature	[°C]
T_{amb}	Ambient temperature	[°C]
$T_{detector}$	Focal plane array (detector) temperature	[°C]
T_{skin}	Skin temperature	[°C]
T_{nasal}	Nasal temperature (in IRTR measurement)	[°C]

T_{tissue}	Tissue temperature	[°C]
T_W	Window temperature	[°C]
T_o	Initial temperature	[°C]
q_m	Body metabolic rate (heat energy)	kcal/day
ΔT	Temperature difference	[°C]
ΔT	Initial temperature difference	[°C]
T_{insp}	Inspired air temperature	[°C]
T_{exp}	Expired air temperature	[°C]
δ_{atm1}	Band transmittance of first atmosphere in incubator NIRT	-
δ_{atm2}	Band transmittance of second atmosphere in incubator NIRT	-
δ_{obj}	Band transmittance of the object	-
δ_w	Band transmittance of the window	-
CPAP	Continuous positive airway pressure	mmHg
RR_T	Respiratory thermal signal	
RH	Relative humidity	%
RWL	Respiratory water loss	mg/kg/min
R_{bottom}	distance to the target from bottom	
R_{up}	distance to the target from above	Cm
$T_d(n)$	Defect temperature	[°C]
$T_s(n)$	Sample temperature	[°C]
EMF	Electromotiveforce	Volt (J/C)
ERT	Exponential registered temperature	[°C]
C(x,y,t)	Contrast of signal	-
B(y)	Photo-energy	-
FOV	Field of View	cm x cm
y1	Shadow projectionof light	-
y2	Dead projection of light	-
y3	Distant light projection	cm
L	Length of the lamps array	cm
LRT	Linear registered temperature	[°C]
NETD	Noise equivalent Temperature difference	[°C]
M_{cam}	Camera parameter for calibration setting	-
$\theta_{resolution}$	IR camera depression angle	radian
R	Radius of the baby	cm
R	Distance to the target	cm
R_w	Window's reflectivity	%
E(t)	Energy of light (PT)	Watt
$\Psi(\omega)$	Fourier transform of the wavelet function	-
Φ_{max}	Maximum source flux for thermography	W/m^2
Φ_{min}	Minimum source flux for thermography	W/m^2
$N_{r.m.s}$	Background signal	-
$\Delta\Sigma$	Measured infrared signal over temperature difference	-
Φ_{obj}	Heat flux emitted by the object	W/m^2
Φ_{refl}	heat flux by reflection from the measured object	W/m^2
Φ_{amb}	heat flux generated by the ambient component	W/m^2
Φ_{cam}	Heat flux emitted by the camera	W/m^2
Sq	Output matrix of the correlation process	-
ω_i	Weighting vector for the tracking image	-

List of abbreviations

Abbreviation	Description
AWT	Adaptive wavelet transformation
AP	Anterior projection
BBR	Black body radiation
BFIRT	Blood flow infrared thermography
CAD	Computer aided diagnosis
CAT	Computer axial tomography
CCD	Charged couples device
cECG	Capacitive ECG
CIE	Codé International Electromagnetique
CO	Carbon monoxide
CO_2	Carbon dioxide
CTS	Corneal thermal signature
CW	Continuous waveform
CWT	Continuous wavelet transformation
DNA	Deoxyribonucleic acid
DWT	Discrete wavelets transformation
ECG	Electrocardiography
ECD	Electrode (abbrv.)
EIT	Electricalimpedancetomography
EM	Electromagnetic (spectrum)
ERS	Electronic recording system
EOM	End of measurement
FEM	Finite element modeling
FIR	Far- infrared
FIRT	Functional infrared thermography
FLIR	Forward looking infrared
FPA	Focal plane array
HFOV	Horizontal Field of View
HRV	Heart rate variability
INCU	Incubator / incubator measurement phase
IR	Infrared
IRTR	Infrared thermography respiration signal
IRT	Infrared thermography
$Incu_1$	First incubator measurement phase
$Incu_2$	Second incubator measurement phase
KMC	Kangaroo mother care
KMC_1	First kangaroo mother care measurement phase
KMC_2	Second kangaroo mother care measurement phase
LP	Lateral projection
LUT	Lookup table
LTI	Linear time invariant
LWIR	Long wave- infrared
MATLAB	Matrix Laboratory
MIT	Magnetic impedance tomography

MTG	Mammothermogarphy
MTF	Modulation transfer function
MRI	Magnetic resonance imaging
MWIR	Middle wave- infrared
NC	Normalized correlation
NICU	Neonatal intensive care unit
NIRT	Neonatal infrared thermography
NIR	Near-infrared
NUC	Non-uniformity correction
NV	Night vision
OOM	Onset of measurement
OP	Oblique projection
PCB	Printed circuit board
PCG	Phonocardiography
PE	Polyethylene
PIRT	Pulsed infrared thermography
PT	Phototherapy (for neonatal medicine)
PUVA	Photochemical Ultraviolet therapy-band A
PPGI	Photopleythsmographic imaging
PUVB	Photochemical Ultraviolet therapy-band B
RMS	Root mean square
ROI	Region of interest
RPT	Ring projection transformation
RTD	Resistance temperature device
SITF	System intensity transfer function
SSC	Skin-to-skin contact
SoC	System on chip
SWIR	Short wave- infrared
TC	Thermocouple
TRL	Total reflection light
TEWL	Transepidermal water loss
TS	Thermal signature
UV	Ultraviolet
UVA	Ultraviolet band-A
UVB	Ultraviolet band-B
UWB	Ultra wide band
VFOV	Vertical Field of View
VLBW	Very low birth weight
VIRSENS	Virtual InfraRed SENSor
WE	Wavelets entropy