



Neonate Bioheat and Mass Transfer in Closed Incubator

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Outline

1. Background and Objectives
2. Approaches
3. Concluding Remarks

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1. **Background and Objectives**
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Preterm Infants

- ❑ 15 million babies are born **preterm** every year (WHO, 2018)
- ❑ Prematurity is a leading cause of **death** due to complications of preterm birth (WHO, 2018)
- ❑ Preterm infants face difficulties keeping a **controlled body temperature** without external assistance
- ❑ Preterm and sick infants risk of **cold stress and hypothermia**
- ❑ Maintain an optimal thermal environment of the neonate is a must
- ❑ More than $\frac{3}{4}$ of premature babies can be saved with feasible, cost-effective care



WHO(World Health Organization)

Taken from CTVNews.ca

Incubators and Radiant Warmers

- Infant incubators and radiant warmers are essential tools to provide thermal comfort for neonates especially premature and sick infants.



Incubator (Atom Med USA)



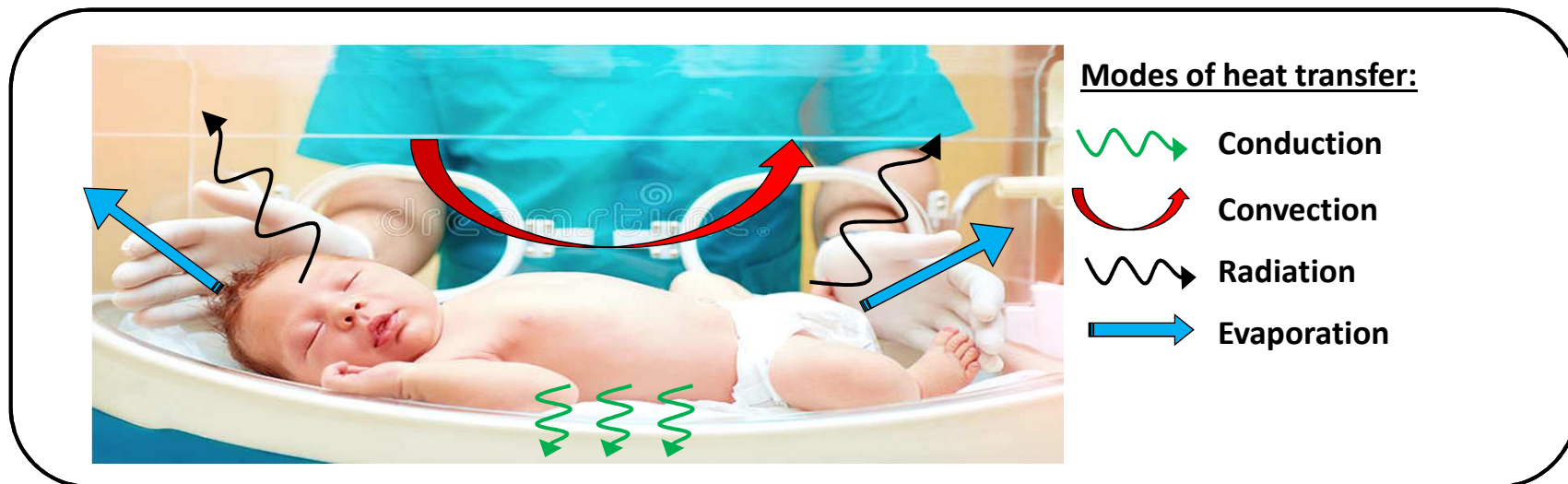
Radiant warmer (Neotech)

Energy Conservation (ΔQ)

The thermal energy in these systems is:

- ✓ Generated by the body through the **metabolic heat**
- and
- ✓ Exchanged with the environment through **conduction**, **convection**, **radiation** and **evaporation losses** from skin and respiratory process

$$\Delta Q = M - K - C - R - E$$



Incubators and Radiant Warmers

Modes of Heat Transfer	Incubator	Radiant warmer
Conduction (K)	Negligible	Negligible
Convection (C)	Gained	Lost
Radiation (R)	Lost	Gained
Evaporation (E)	Moderate	Elevated
Pros	Closed chamber Controlled environment Used for preterm babies	Easy access
Cons	Bulky and expensive	Ambient disturbances Possible infections Humidity control



Problem Statement

- ❑ Absence of continuous monitoring of these neonates in (NICU) increases the survival rates and results in a better developmental outcome
- ❑ The many wires creates a negative environment which disturb the neonate
- ❑ The ventilation is not optimized and needs to be enhanced
- ❑ Need for new generation of monitoring and data acquisition systems

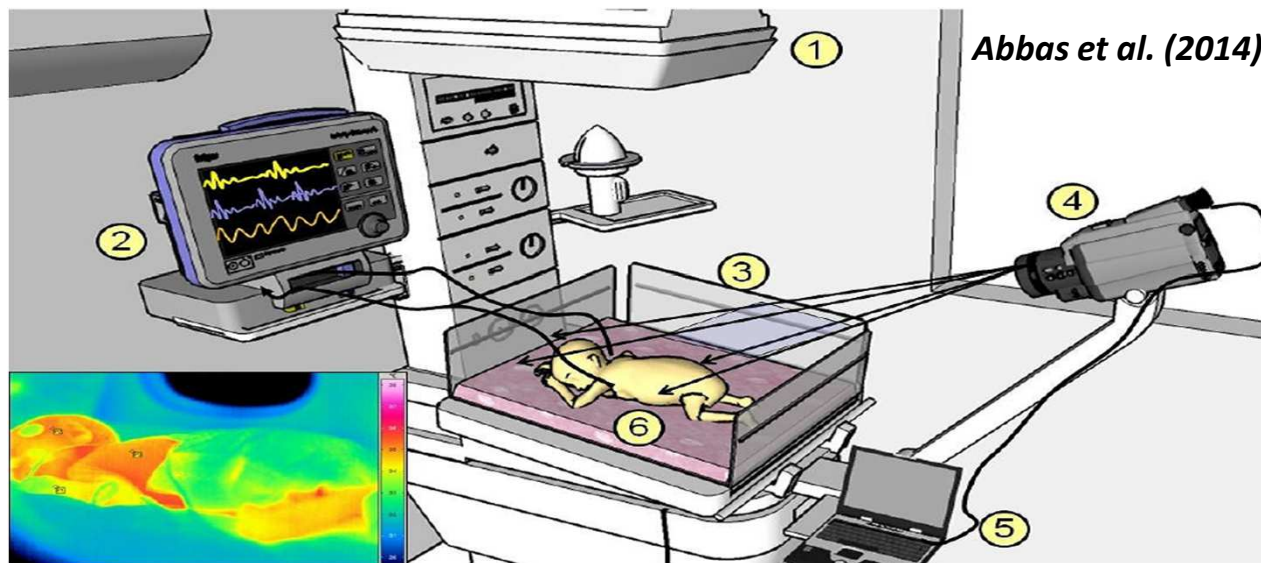


NICU: (Neonatal Intensive Care Unit)

Bonner et al. (2017)

Objectives

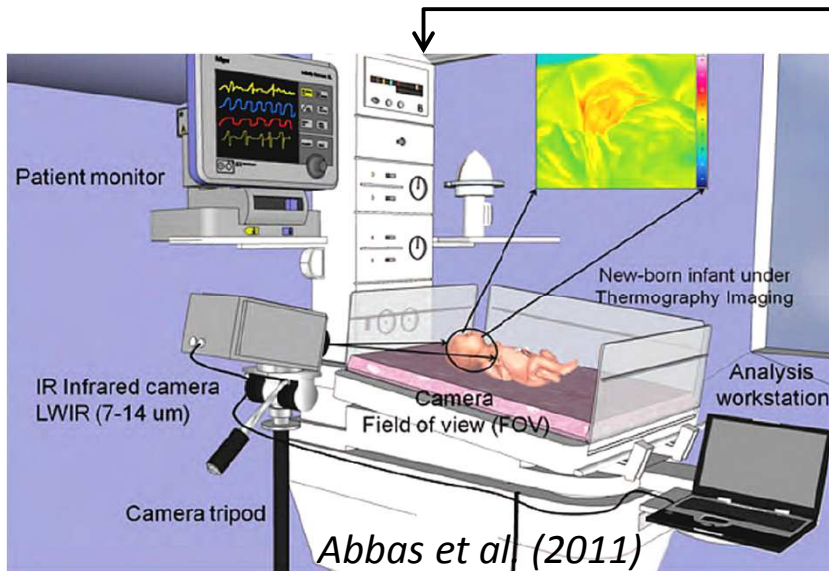
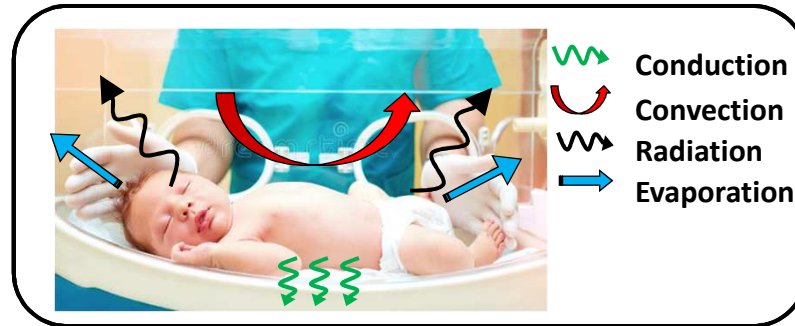
- ❑ Use remote sensing methods such as infrared thermography to obtain the local temperature distribution
- ❑ Modify incubator design for enhanced and localized ventilation such as air curtains
- ❑ Incorporate intelligent technology with deep learning for prediction and fast decisions



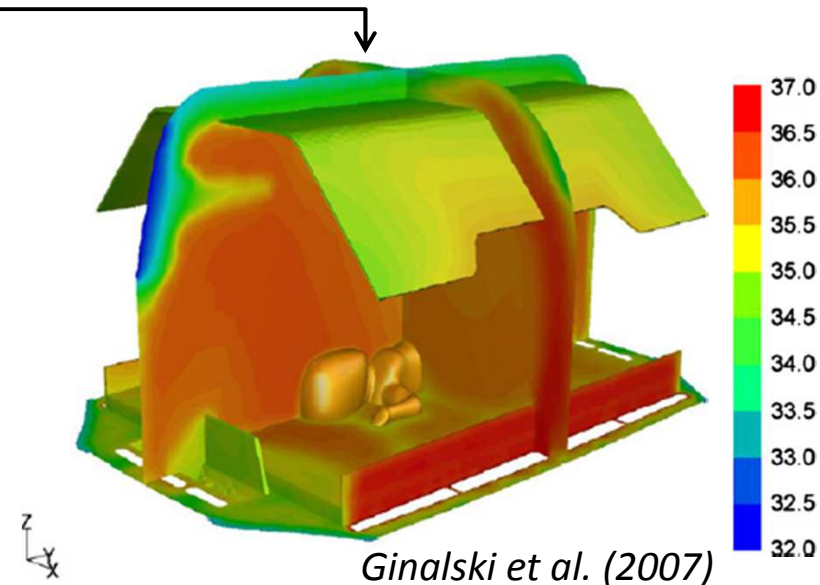
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Approaches



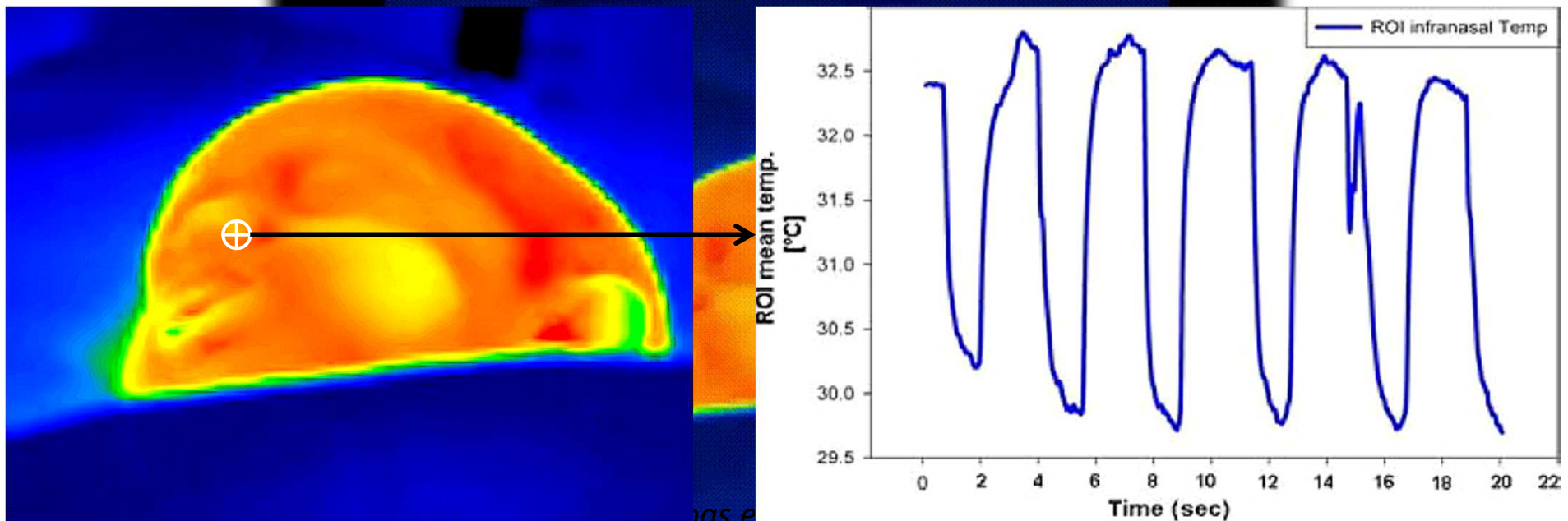
Experimental Analysis



Numerical Analysis (CFD)

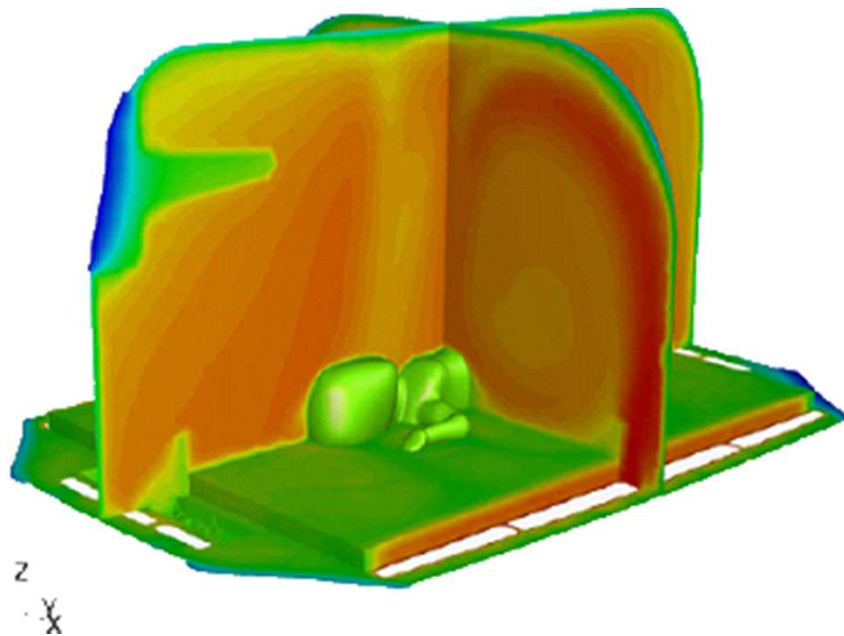
Experimental Study

- ❑ Build a manikin with sweating capability
- ❑ Build an incubator with sensors and control instrumentation
- ❑ Implement infrared thermography, thermocouples and psychrometer
- ❑ Integrate deep learning for better data analysis and faster decision

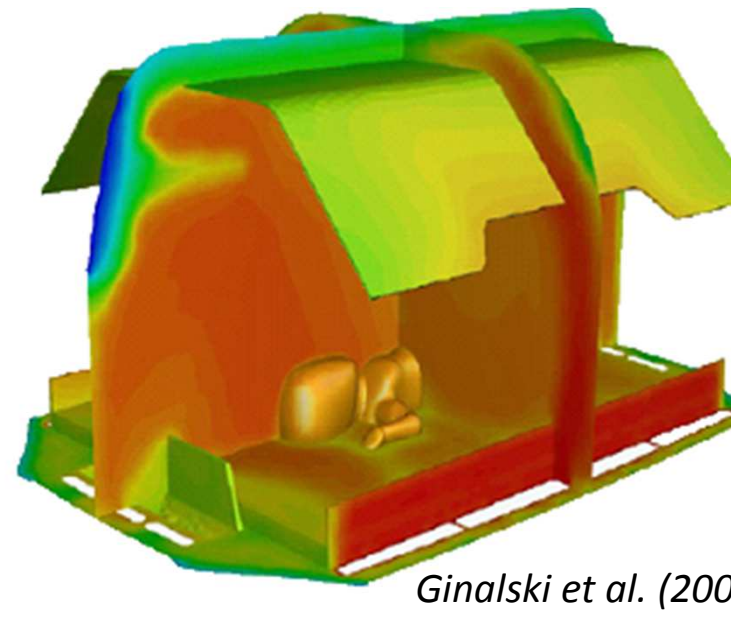


Numerical Study

- ❑ Compute Navier-Stokes and energy equations using CFD
- ❑ Understand and analyze the flow structure
- ❑ Optimize the ventilation system
- ❑ Locate the remote sensors



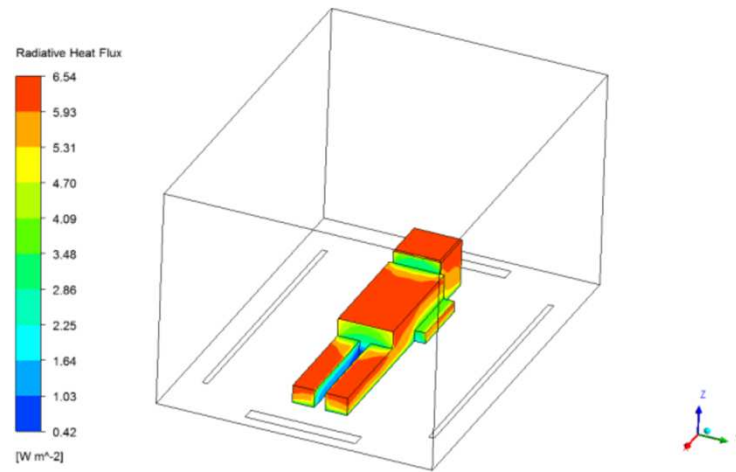
Without overhead screen



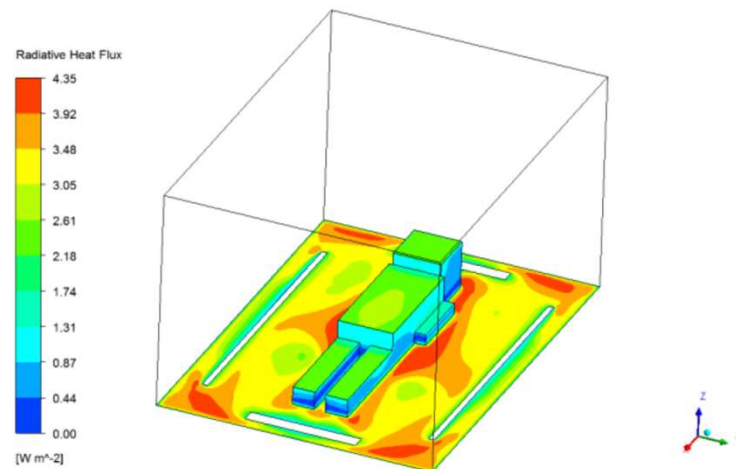
Ginalski et al. (2007)

With overhead screen

Numerical Study



Case 1: adiabatic mattress



Case 2: heated mattress

Hannouch et al. (2016)

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Concluding Remarks

- Numerical analysis of heat and mass transfer for neonate inside incubator
- Use non-contact or remote sensing methods to enhance comfort of neonate inside incubator
- Automated temperature and humidity control for enhanced and localized ventilation
- Incorporate intelligent technology with deep learning for data acquisition



Thank You

