<div align="center">論文審査の要旨および担当者</div>

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論文審査担当者：	主査	Keiko Okawa (Professor, Keio University Graduate School of Media Design)	
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（論文審査の要旨）

Thesis Title: Thermal Suite: Investigating Temperature Modality in Mixed Reality

The thesis submitted by Kirill Ragozin presents "Thermal Suite", a novel design to enable temperature as an interaction modality and to provide a way of seamlessly integrating it into the mixed reality medium. It makes a case for using it in combination with other unconventional interaction techniques, observes the psychological effects that occur, and discusses what can be achieved by integrating cutaneous feedback mechanics into virtual and augmented reality experiences.

Thesis Structure
The dissertation is written as a design dissertation consisting of seven chapters.
Chapter 1 begins with a brief overview of the research domain by clearly defining the terminology such as mixed reality, somatosensory system, perception. Chapter 2 summarizes the related works in mixed reality, a physiological background of the sensory system and interaction modality to further discuss the recent research about thermal feedback. It also gives an overview of the immersive media industry, innovative technologies and challenges. Chapter 3 proposes the concept of Thermal Suite as a collection of wearable hardware to provide variations of thermal feedback mechanics to the users in mixed reality. It also shows the prototype design and implementations. Chapter 4 focuses on thermal perception and presents a thermal perception experiment creating a usable thermal feedback model for the hardware prototype family featured in mixed reality experiences. Chapter 5 outlines various development stages of the wearable thermal prototypes and features a series of mixed reality experiences and public demonstrations. Chapter 6 proposes a classification of the interactions based on the ones explored throughout this research and outlines a set of design guidelines that aim to ease introducing these techniques into future mixed reality projects. Finally, Chapter 7 discusses this work's implications, its limitations and future research and development opportunities.

Contributions, Impact, and Significance
Kirill Ragozin explores how to integrate temperature more seamlessly into spatial virtual, augmented and mixed reality experiences. He created several design prototypes, guidelines and toolsets focusing on thermal feedback modality that simplify the process of creating immersive multisensory experiences for programmers and mixed reality designers.
In summary, there are four significant contributions of the dissertation.
First, Thermal Suite demonstrated its ability to provide thermal feedback that can be easily integrated with modern mixed reality engines. Second, a model of thermal perception will contribute to simplifying the designing process of thermal feedback mechanism. Thirdly, a taxonomy of somatosensory interactions with the recommendations for introducing thermal cutaneous feedback mechanics into immersive media applications. Lastly, this research outcomes demonstrated the new position of the multisensory interaction mechanics in mixed reality, which features thermal sensations that will open the door to the next stage of this technology integration into the applications.

Overall, the thesis is well published (10 papers accepted at international academic conferences, some with very low acceptance ratee.g. Siggraph Etech, IEEEVR, MobileHCI). In addition, the tools and prototypes produced during the thesis (e.g. Unreal Engine thermal design editor) are actively used by other researchers/designers.

The topic itself is timely, relevant, and important for Human-Computer Interaction, Virtual/Mixed Reality, and related research fields. The work has also broader social implications and impact.

Summary
The review committee came to the conclusion that the contributions of the dissertation in relation to social impact, research output and quality meet the requirements for a PhD in Media Design.

Assessment Process:

1. The doctoral dissertation proposal defense was held online on June 26th, 2020 13:00-14:00 JST. The dissertation advisory committee examined and judged the result based on the proposal and the oral examination. The result was approved by the KMD graduate school committee on July 18, 2020.

   The principal advisor: Kai KUNZE
   The member of the advisory committee: Keiko OKAWA, Matthew WALDMAN

2. The public doctoral dissertation defense was held online on December 21, 2020 21:30 - 23:30 JST. After the defense, the final assessment by the doctoral dissertation review committee and the dissertation advisory committee conducted in a separate room online and concluded the decision to approve.

   The followings are the participants of the public doctoral dissertation defense:
   - 4 members of the doctoral dissertation review committee
   - The principal advisor
   - 8 other participants