東北大学 電気通信研究所

研究室外部評価資料

(2013 年度-2018 年度)

Activity Report of Research Laboratory for External Review

April 2013 - March 2019
(FY.2013-2018)

Research Institute of Electrical Communication Tohoku University

情報コンテンツ研究室
Information Content

April 2013 - March 2019 (FY. 2013-2018)

A. 研究室名 / Research Laboratory

情報コンテンツ研究室 / Information Content

B. 構成員 / Faculty and Research Staff (as of May 1, 2019)

※ 欄を適宜追加削除等調整して下さい．期間内に異動等があった場合には，在籍期間を記載して下さい．

教授 / Professor	
氏名 Name	北村 喜文 Yoshifumi Kitamura (April 2010 -)
分野名 Research Field	インタラクティブコンテンツ設計研究分野 Interactive Content Design
准教授 / Associate Professor	
氏名 Name	高嶋 和毅 Kazuki Takashima (April 2011 -)
分野名 Research Field	ヒューマンコンテンツインタラクション研究分野 Human-Content Interaction
助教 / Assistant Professor	
氏名 / Name	藤田 和之 / Kazuyuki Fujita (July 2018 -) 上出 寛子 / Hiroko Kamide (April. 2015 - July 2016)
他 / Others	
	産学官連携研究員: 1 名 (April 2012 - 2013) 日本学術振興会特別研究員 DC1: 1 名 (April. 2016 -)

C. 研究目的 / Research Purpose

本研究室では，デジタル化されているものだけでなく，身の回りのあらゆるものをコンテンツと捉え，これらを活用して人々が快適に，または効率的・直感的に作業をしたり，円滑かつ豊かなコミュニケーションができるようにするために，人と空間（およびその構成物）のインタラクションを考慮して，インタラクティブコンテンツに関する研究を進めている．

Our research group’s goal is to improve people lives through content design. We view all artifacts, physical and digital, as content. Honoring the unique perspectives of people, systems, and the environments they inhabit, we study the interactions between types of content, with the ultimate goal of formulating cohesive, holistic, and intuitive approaches that promote efficiency, ease of use, and effective communication.

D. 主な研究テーマ / Research Topics

1. 視覚・物理的に適応可能な空間ディスプレイ・ユーザインタフェース
2. インタラクティブなコンテンツの可視化
3. 3 次元モーションセンシングとインタラクション
4. ブロック型ユーザインタフェース
5. 運動学に基づくインタラクション技術
6. ドローンを活用する新しいインタラクティブコンテンツ

1. Visually and Physically Transformable Displays/User Interfaces
2. Interactive Content Visualization with Emerging Algorithms
3. 3D Motion Sensing and Interaction
4. Block-based Tangible User Interfaces
5. Kinematics-based Content Manipulation Techniques
6. Interactive Drone Content for Entertainment / Wildlife Symbiosis

E. 学術論文等の編数 / The Number of Research Papers							
	2013	2014	2015	2016	2017	2018	Total
(1) 査読付学術論文 Refereed journal papers	2	7	2	5	4	1	21
(2) 原著論文と同等に扱う 査読付国際会議発表論文 Full papers in refereed conference proceedings equivalent to journal papers	4	1	4	2	2	3	16
(3) 査読付国際会議 Papers in refereed conference proceedings	2	6	6	1	5	12	32
(4) 査読なし国際会議・シンポジウム等 Papers in conference proceedings	0	0	1	0	1	0	2
(5) 総説・解説 Review articles	3	0	1	1	1	0	6
(6) 査読付国内会議 Refereed proceedings in domestic conferences	2	4	1	2	3	3	15
(7) 査読なし国内研究会・講演会 Proceedings in domestic conferences	7	7	6	7	7	4	38
(8) 著書 Books	0	0	0	0	0	0	0
(9) 特許 Patents	0	0	1	0	0	1	2
(10) 招待講演 Invited Talks	4	5	6	6	7	3	31

F. 特筆すべき研究成果 / Significant Research Achievements (FY.2013-2018)

See Ref. 1. "#" mark indicates research carried out at a former organization.

2013-2018 年度の研究成果（論文・特許など）のうち，前半（2013-2015 年度）と後半（2016-2018 年度）それぞれで代表的な数件（2-3 件程度ずつ）について，参考資料を引用して，その特徴と学術的意義などを簡単に紹介する．英文のみ，もしくは和文と英文で記載.

要約は 300 字程度．論文誌の要約/Abstract のコピー可．学術面での国際的インパクトならびに社会的影響を 100 字程度で記載.

必ずしも当該期間内に発表・出版したものに限るのではなく，例えば過去に発表したものでもこの期間内に成果が得られたり，評価されるようになったりしたものも含むものとする．

インパクトファクターや被引用件数など，できる限り第三者が定量的に評価できる指標を用いてアピールすること．それらの指標にはそぐわない場合には，その事情とそれに変わる適当な評価指標・尺度を示すこと．

[2013-2015]

1. Kazuki Takashima, Naohiro Aida, Hitomi Yokoyama and Yoshifumi Kitamura, TransformTable: a self-actuated shape-changing digital table, *Proceedings of Conference on Interactive Tabletop and Surface (ITS)*, pp. 179 - 187, October 2013.
   [(HCI 分野での 22 位の国際会議/ 673 件)], [Cited: 23] [Top 10% Paper]

   TransformTable は，我々が世界で初めて設計開発して発表したテーブル面の形状の自律変形が可能なインタラクティブデジタルテーブルである．社会心理学的知見に基づいて設計され，テーブル面を正方形，長方形，円形の三種類のうち一つに機械的に変形することができる．テーブル面はタッチスクリーンとなっており，従来のデジタルテーブルの機能を大幅に向上させるとともに，什器の新たなあり方を提案した挑戦的な論文である．その挑戦性から，特に Shape-changing Interface の研究者らに注目されており，今後活発になるであろうスマートルームや IoT などの基盤技術につながる学術的なインパクトを有している．
   なお，本論文は引用指標上 Top10%論文(RIEC 研究推進委員会の調査)である．

   Our TransformTable project is considered the first realization of an interactive transformable digital table, whose shape of tabletop can be physically and dynamically deformed according to content and task. TransformTable can deform from/into one of three typical shapes: round, square, or rectangular, using automatic electromechanical shape actuation for its transformations. TransfomTable represents digital information in a physically changeable screen shape and simultaneously generates, or adheres to, different spatial arrangements of users around the table. This paper presented a novel concept of smart deformable furniture that changes our spatial behaviors, implemented and evaluated a fully functional prototype, and tackled the related electromechanical technical challenges.

   This paper is cited frequently by HCI researchers working on large scale shape-changing user interfaces, and regarded as a top 10% paper based on the citation index (according to the report of RIEC's research promotion committee). This paper has sufficient academic impact for further researches on transformable display/furniture, smart room etc.

2. Chi Thanh Vi, Kazuki Takashima, Hitomi Yokoyama, Gengdai Liu, Yuichi Itoh and Sriram Subramanian, and Yoshifumi Kitamura: Dynamic Flexible and Interactive Display Method of Digital Photographs, Entertainment Computing, Elsevier, Volume 5, Issue 4, December 2014, Pages 451-462, 2014

   写真群を柔軟にかつインタラクティブに表示するシステムである．本研究は，Prof. Subramanian (当時，英国・ブリストル大，現在サセックス大)との共同研究であり，写真群の提示アルゴリズムとその効果を脳波により計測した結果を報告しているユニークな論文である．D-FLIP: Dynamic & Flexible Interactive PhotoShow というタイトルで，国際会議 Advances in Computer Entertainment Technology (ACE)で口頭発表（論文は Proceedings of Conference on Advances in Computer Entertainment Technology, pp. 415-427, Nov. 2013 に掲載）したところ，Honorable Mention Award を受賞し，本論文誌に推薦されたので，内容を充実させて再投稿した．
   本研究はこれまで国内外の企業や大学などとの多数の共同研究に結びついている．例えば，これまでに 4 件の企業との共同研究に繋がり，うち 2 件は商品化に至り，そのうち 1 件は知財収入を大

学にもたらすなど，産業的インパクトは高い．それだけではなく，例えば，動的コンテンツの印象を脳波計測（富山県立大），高齢者向けのインタラクティブな写真表示による認知症予防ツール（国立台湾大学），タイピングができない人々を対象にしたｅコマースシステム（インド工科大学），高齢者向け写真閲覧システム（タイ・チュラーロンコーン大学）との国内・国際共同研究に発展しており，研究室の中でも最も対外的にアピールできている研究の 1 つである．

This paper presents D-Flip, a new photo arrangement algorithm that dynamically, flexibly and interactively manages a large photo collection. The paper's approach is unique as it combines a proposed algorithmic approach with a biological evaluation based on sensing brain signals. The project was conducted in collaboration with Prof. Subramanian at Univ. of Bristol (currently at Univ. of Sussex, UK) and its functional and elaborate prototype was demonstrated repeatedly in various venues over the years. This work was firstly presented at International Conference of Advances in Computer Entertainment Technology (ACE) (Proceedings of Conference on Advances in Computer Entertainment Technology, pp. 415-427, Nov. 2013), and won the Honorable Mention Award; therefore, it was recommended to Elsevier Journal of Entertainment Computing.

D-Flip is one of the most successful projects in our lab when it comes to its measurable social and industrial impact. We have had four industrial collaborators around D-FLip; Two of them have offered commercial products in the market, one being quite successful and providing continuous revenue to the university based on our patent, which is quite exceptional for a research project. Additionally, D-Flip attracted many academic collaborators for a variety of aims such as content evaluation by brain signal (Toyama Prefecture Univ.), shopping interface for non-typing people (Indian Institutes of Technology), and photo browsing tool for elderly people (National Taiwan Univ. and Chulalongkorn Univ. Thailand). Each of these D-Flip subprojects is expected to be disseminated in the near future.

3. Jiawei Huang, Tsuyoshi Mori, Kazuki Takashima, Shuichiro Hashi and Yoshifumi Kitamura, IM6D: magnetic tracking system with 6-DOF passive markers for dexterous 3D interaction and motion, ACM Transactions on Graphics (TOG) - Proceedings of ACM SIGGRAPH Asia 2015, Volume 34, Issue 6, pp. 217:1-217:10, November 2015. [IF: 4.21], [Cited: 20]

本研究は，通研 石山・杉研究室との共同研究であり，IM6D と呼ぶ新たな磁気式のモーショントラッキングシステムの研究開発成果である．本研究では，世界で初めて，電源不要の識別可能なパッシブマーカを 15 個（それぞれで 3DOF, 三つ組み合わせれば 5DOF）を同時に 100Hz 程度で計測することができるモーショントラッキングシステムを発表した．この成果は，手指の細かな計測や遮蔽が発生しやすいモノの計測など，従来の光学または磁気式システムでは難しかった対象の計測を可能にするものであり，技能理解を始めとした様々な応用が期待されるものである．

本成果は，コンピュータグラフィックスとインタラクティブシステムで最も権威あるトップ国際会議 SIGGGRAPH Asia にフルペーパとして採択され発表したものである．なお，論文は ACM デジタルライブラリから PDF ダウンロード数が多いことから，2016 年 4 月から 7 月までの間，Digital Library Selections に注目論文として掲載されるなど，世界的に強い注目を集めている．本成果は，これまで計測できなかったために解けなかった諸問題の解決に糸口を与えることができるため，科研費基盤 A（代表: 北村）の連続獲得につながるなど，未踏計測問題の解決に向けて今後の期待度も高い．

In this paper we presented IM6D, a novel real-time magnetic motion-tracking system using multiple identifiable, tiny, lightweight, wireless and occlusion-free markers. Our work on IM6D utilizes a novel electromagnetic induction principle to externally excite wireless LC coils and uses an externally located pickup coil array to track each of the LC coils in 5-DOF. Our paper further details how this principle can be applied in practice to design a 6-DOF motion-tracking system using multiple markers, providing reliable tracking with reasonable speed. We outline the implementation of functional tracking system based on our approach, and the application of a parallel computation algorithmic methodology approach in order to increase the tracking speed. We also built some examples to show how well our system works in actual situations.

IM6D was the first high-dimensional magnetic motion tracking system using passive wireless markers that can detect dexterous motions. This work was presented at SIGGRAPH Asia 2015 as a full paper, and was later

selected as a ACM Digital Library Selection, and repeatedly demonstrated by our lab in various venues. Our IM6D project later led to our lab securing the academic JSPS Kakenhi A funding (PI: Kitamura) and is expected to solve unexplored tracking problems in engineering and scientific areas. This project is a collaborative project with Prof. Ishiyama and Hashi's lab in RIEC.

[2016-2018]

1. Kazuki Takashima, Takafumi Oyama, Yusuke Asari, Ehud Sharlin, Saul Greenberg and Yoshifumi Kitamura, Study and design of a shape-shifting wall display, Proceedings of ACM Conference on Designing of Interactive Systems (DIS), pp. 796 - 806, June 2016. [Honorable Mention Award]. (HCI 分野での 8 位の国際会議/ 673 件) [Cited: 12]

作業空間におけるディスプレイ面の形状の重要性に着目し，作業の内容や状況に応じて自律的に移動しその配置を変更することが可能な壁型ディスプレイ（自律変形壁型ディスプレイ）について検討した結果を報告した論文である．まず，デザインスタディにより，ユーザによる壁型ディスプレイの利用形態を調査した．その結果，作業場面に応じてユーザは平面以外の様々なディスプレイ形状を求めることが分かり，自律変形壁型ディスプレイの設計にあたって重要となる形状や，変形方法の指針を得た．また，その指針に基づき，様々なユーザの要求やコンテキスト（ユーザの意図，表示コンテンツ，周囲の状況）に応じて自動的に変形し，快適な作業空間を提供する自律変形壁型ディスプレイおよびインタフェースのプロトタイプを実装し，その利用シナリオについて議論した．

本成果は，空間におけるディスプレイと人のインタラクションに関する研究分野のパイオニアであるカルガリー大学の Prof. Saul Greenberg と Prof. Ehud Sharlin との共著論文であり，彼らとの共著であること自体に大きな国際的なインパクトを持つ．そして，HCI分野，特にインタラクションデザインに特化したトップカンファレンスとして認識されている国際会議 DIS (Designing Interactive Systems，同分野 8 位/680 会議）にて採択され（採択率 26%），かつ 416 件のうち上位 5%に与えられる Honorable Mention Award を受賞するなど，国際評価は高い．また，改定と翻訳を経て投稿した情報処理学会論文誌においても，改定無の採録かつ特選論文を受賞するなど，国内のコミュニティに置いても高い学術的インパクトを持つ．

In the shape-shifting wall display project we designed a dynamic wall display that changes its form interactively to various configurations. Shape-shifting is controlled either by explicit interaction (where the display responds to hand gestures) or implicitly (where the display infers a shape based on its content as well as on the sensed positions of the people around it). Our project contributed a study that motivates research on shape-shifting wall displays, and a shape-shifting display system that responds to explicit and implicit controls to match particular activities.

This is a collaborative work with strong HCI and HRI researchers; Prof. Saul Greenberg and Dr. Ehud Sharlin of the University of Calgary's Interactions Lab. Dr. Greenberg, an ACM CHI Academy member, is well-known as one of the founders of HCI, ubiquitous computing and CSCW, and collaborated closely with Prof. Takashima and our lab members on this project. The work was accepted and presented by Prof. Takashima at the conference on Designing Interactive Systems (ACM DIS), a top conference of interaction design (acceptance rate 26%). Our paper received an Honorable Mention Award (top 5% of 416 submissions). An considerably extended paper on the project in Japanese was submitted to a domestic journal, received a strong accept decision and later selected as a Specially Selected Paper (equivalent to best paper award). The paper generated considerable interest in the community and was cited by several follow-up projects on shape-shifting displays in recent ACM SIGCHI venues.

2. Daigo Hayashi, Kazuyuki Fujita, Kazuki Takashima, Robert W. Lindeman and Yoshifumi Kitamura, Redirected Jumping: imperceptibly manipulating jump motions in virtual reality, Proceeding of IEEE Conference on Virtual Reality and 3D User Interfaces, 11 pages, March 2019 (The official version will appear on IEEE Xplore DL) .

バーチャルリアリティ（VR）技術の応用範囲をより広げるための研究である．一般に VR では無限に広い空間を扱うことが多いが，利用者が存在する空間は部屋の大きさや人の動きの計測範囲に限界があることから，両空間の差異を錯覚を活用して知覚的に埋める研究が盛んに行われてきた．様々な研究例がある中で，我々は跳躍というユニークな動作に着目し，ユーザの跳躍動作における距離，高さ，回転角などの物理量を一定のゲインにより拡大または縮小してバーチャル環境内の映像に反映させる手法を提案し，ユーザに知覚されずに提示可能なゲインの大きさを，実験により明らかにした．

IEEE Virtual Reality は，近年世界的に注目が高まり続けている学術分野であるバーチャルリアリティ（VR）分野で，古くからトップカンファレンスである．2019 年の Conference paper track の採択率は 21%（採択 95 件/投稿 442 件）と極めて難関であるが，高評価（7 点満点中 4 人の査読者平均 5.25，メタ査読者は 6 点）でそれを通り抜けたこと自体に大きな学術的インパクトがあると言え，また，今後広い読者を得ると予想される．本研究で得られた知見は，VR 技術の普及に向けた物理空間の制約や安全性の問題を解決に導くものであり，様々な産業，社会的価値が期待できる．

This paper explores Redirected Jumping, a novel redirection technique which enables us to purposefully manipulate the mapping of the user’s physical jumping movements (e.g., distance and direction) to movement in the virtual space, allowing richer and more active physical VR experiences within a limited tracking area.

Redirected Jumping was published in IEEE VR, the top conference in the virtual reality (VR) field, with 95 papers accepted out of 442 submissions (21% acceptance rate) in IEEE VR 2019. Redirected Jumping contributes a solution for physical space constraints and safety issues for physical jumping VR interaction techniques, and has potential to create significant application and social impacts in the field.

G. 特筆すべき活動 / Significant Activities (FY.2013-2018)

See Ref. 2-9. "#" mark indicates research carried out at a former organization.

研究室外部評価参考資料の 2 以降を参照しながら，2013-2018 年度のなどの活動の中から特筆すべきものを取り出し，前半（2013-2015 年度）と後半（2016-2018 年度）に分けて簡単に紹介する．英文のみ，もしくは和文と英文で記載.

Our lab is unique in the active role it takes in community building, following a vision of the field of interaction design being an inclusive, open and innovative research domain that can enable researchers create without borders and boundaries, helping society as a whole.

We practice this vision every day through strong collaboration with several interaction design labs around the globe, by hosting a large number of leading international researchers in our lab, providing them with ample opportunities to collaboratively work on research projects with our lab members, by our firm commitment to representation of international students in our lab, and by strongly adhering to principles of inclusivity, diversity and equality in our lab membership, and in our research (please see more chronological details, below)

[2013-2015]

We outline major activities of our lab and members during 2013-2015.

- Extensive effort for supporting the community
  - ACM SIGGRAPH Asia 2015 @Kobe directed by Prof. Kitamura as Conference Chair.
  - Japan Liaison for IFIP (International Federation for Information Processing) TC-13 (Technical Committee on Human-Computer Interaction) by Prof. Kitamura.
  - Conference organizers and international program committees in many of VR/HCI related conferences such as ACM SUI, ITS, VRST, and IEEE VR, 3DUI, and INTERACT, and so on.
- Interdisciplinary and international collaborations (and fund)
  - Inviting social scientist, Dr. Hitomi Yokoyama, as a post-doctoral researcher in the lab, led to an interdisciplinary paper of TransfromTable which is now regarded as a top 10% paper. She is now an associate professor of the department of management of Okayama University of Science after her five-year human behavior sensing research experiences at Tokyo University of Agriculture and Technology. The lab keeps strong research connection with her and recently our co-authored journal paper on human behavior sensing got accepted in the domestic journal society.
  - Social scientist, Dr. Hiroko Kamide joined us as an assistant professor (April 2014 - June 2016), expanded our physiological work and added new perspective of human robot interaction. She is now a permanent associate professor at Nagoya University
  - Keep collaboration with Ishiyama and Hashi laboratory at RIEC, led to a research fund JSPS Kakenhi A, and publications in SIGGRPAH 2013 E-tech and SIGGRAPH Asia 2015 full paper
  - 6 months visiting professor position by Kazuki Takashima, assistant prof. in University of Calgary, which led to several collaborations with famous researchers and publications with international co-authors.
  - Strong collaboration for block-user interface assessing children's inner states, with Prof. Tomoaki Adachi at Miyagi Gakuin Women's University, a developmental psychologist
  - Keep managing many Collaborative research projects of the RIEC (listed in 9 (3))
- The lab is open for any guests
  - frequently accepting visitors from any fields such as students, company and officers, and live demonstrations of our work are always provided.
- Industrial Impact
  - ふわっと signage by Oki Electric Industry became a commercial product based on our D-Flip project and this sales result is successful and creating constant running royalty to the university and lab.
  - Web core innovation suite by Fujitsu SSL became a commercial product based on our D-Flip project.
- Diversity of students
  - Accepting many short-term or long-term international and exchange students from all over the world.
  - Making the lab attractive for female students. The percentage of female students of our lab is regularly higher than the average of other engineering or computer science labs.

[2016-2018]

We outline major activities of our lab and members during 2016-2018

- Extensive effort for supporting the community:
  - Conference organizers and international program committees in the VR/ HCI related conferences such as SIGGRAPH E-tech, SIGGRAPH Asia, SUI, ICAT-EGVE, ITS/ISS, VRST, INTERACT, and IEEE VR etc.
  - Establishing Japan ACM SIGCHI Chapter (Prof. Kitamura, Chair)
  - Forming and running the SIGCHI Asian Development Committee (Prof. Kitamura, Chair)
  - Inviting CHI 2021 conference, the biggest international conference in the HCI domain with approximately 3000-4000 attendee, to Yokohama, Japan (Prof. Kitamura will serve general co-chair)
  - Japan Liaison for IFIP (International Federation for Information Processing) TC-13 (Technical Committee on Human-Computer Interaction) by Prof. Kitamura.
  - Organizing three-day IPSJ Symposium: Entertainment Computing 2017 (Attendance: over 300) in the RIEC building, directed by Prof. Kazuki Takashima as local and symposium chair.
  - Serving organizing committees for annual conference of Virtual Reality Society of Japan 2018
- Active collaboration with academic and industrial partners.
  - Keep publishing papers with international collaborators (co-authors).
  - Keep establishing social relations to the outside of the lab, not only for academia but industrial collaborators. For example, Kazuyuki Fujita, who is now our assistant professor joined our lab after 4-year experiences of industrial researcher at an interior company.
  - Expand the collaboration with Ishiyama and Hashi lab of RIEC and start a collaboration with Prof Katayama at Tohoku University, led to a research fund JSPS Kakenhi A (Prof. Kitamura).
  - Activate a new collaboration with Koh Sueda from National University of Singapore about drone project, led to a three-year research fund from RIEC and a top-tier conference full paper (UIST 2019).
  - Four-years collaboration with Fujitsu Social Science Laboratory Limited (-2018) led an important product and exhibition system (see below).
  - Collaboration with NTT Docomo Inc. on smartphone interface, led to a joint patent application and a demonstration publication with a best demo award at a domestic conference for only 5-months research period.
  - Keep the collaboration for block-user interface with Prof. Tomoaki Adachi at Miyagi Gakuin Women's University, led to a two-year research fund of sensor embedded toy block development.
  - Keep managing many collaborative research projects of the RIEC (listed in 9 (3))
- Industrial/social impact
  - Academic advisor for 日本文教出版, a company of educational content. We help them their product on art appreciation tool based on our D-Flip system. They will sale soon.
  - Earning running royality of ふわっと sinage @Oki Electric Industry to Tohoku University and icd-lab based on our collaboration (-2017)
  - Web core innovation system, based on our collaboration with Fujitsu Social Science Laboratory Limited, has been renamed and deployed in the Fujitsu's coworking concept room: digital transformation center https://www.fujitsu.com/jp/about/corporate/facilities/dtc/
- Diversity of students
  - Accepting many short-term or long-term international and exchange students from all over the world. We kept working with some of short-term students after they came back to the home country and a couple of results have been published.
  - Emphasizing gender equality and inclusivity in our membership (with 29 female research students, one female postdoctoral fellow and one female Faculty member during the report period. Our lab's female representation is considerably higher than the average of other Japanese Engineering and Computer Science labs.
- Students' high activity
  - Respecting self-initiative of students and encourage them to work on their side projects as long as their time and resource are permitted, which led many hackathon participations with award winners and student volunteer participation to international conference (listed in 9(7))