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

生体電磁情報研究室

Electromagnetic Bioinformation Engineering

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

A. 研究室名 / Research Laboratory

生体電磁情報研究室
Electromagnetic Bioinformation Engineering

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	石山 和志 Kazushi Ishiyama (April 2007 -)
分野名 Research Field	生体電磁情報研究分野 Electromagnetic Bioinformation Engineering
准教授 / Associate Professor	
氏名 Name	枦 修一郎 Shuichiro Hashi (June 2010 -)
分野名 Research Field	生体電磁材料研究分野 Electromagnetic Biomaterial Engineering
助教 / Assistant Professor	
氏名 / Name	林 禎彰/ Yoshiaki Hayashi (April 2016 – March 2019)
他 / Others	
	産学官連携研究員: 2 名 (June 2013 – Mar. 2014, Oct. 2015 – Mar. 2018) 日本学術振興会特別研究員 PD: 1 名(Oct. 2018 – Nov. 2018) 日本学術振興会特別研究員 SPD: 0 名 日本学術振興会海外特別研究員: 0 名

C. 研究目的 / Research Purpose

本研究室では，磁気的微細構造を制御した磁性体を利用し、磁気が本質的に有する特徴を活かしたデバイスを開発することで、生体あるいは電気機器の発する電磁界を情報として捕らえるための超高感度センサおよびシステムの確立、ならびに生体情報を能動的に取得するためのシステムの確立を目指して研究を遂行する。これらの研究を通じて、生体の発する情報を受け取る技術ならびに生体に対して働きかけを行う技術の確立を目指す。

For realizing good communication with human body, and for realizing the properties of the human body as an information system, we have to realize the function of the human body as information in addition to catch the signals from the human body. Our research division works on the technology for sensing the information from the human body and for approaching action to the human body. We are focusing to realize the communication technology with human body and to contribute information and communication systems and medical-welfare spheres.

D. 主な研究テーマ / Research Topics

1. マイクロ磁気アクチュエータ・磁気利用次世代医療機器開発の研究
2. を用いた微小振動計測システムの開発に関する研究
3. 高周波電磁界計測技術に関する研究
4. ワイヤレス磁気センシングシステムとその応用に関する研究
5. 高感度磁界センサに関する研究

1. Study of Micro magnetic actuator and New medical equipment using magnetics
2. Development of high sensitive microvibration measurement system, fabrication of high sensitive strain sensors
3. Development of High-frequency electromagnetic measuring system
4. Development and application of Wireless magnetic sensing system
5. Development of Super high sensitivity magnetic field sensor

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	8	4	6	3	5	3	29
(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	0	1	0	0	0	0	1
(3) 査読付国際会議 Papers in refereed conference proceedings	9	12	3	3	5	2	34
(4) 査読なし国際会議・シンポジウム等 Papers in conference proceedings	0	0	0	0	0	0	0
(5) 総説・解説 Review articles	0	0	0	0	0	0	0
(6) 査読付国内会議 Refereed proceedings in domestic conferences	0	0	0	0	1	0	0
(7) 査読なし国内研究会・講演会 Proceedings in domestic conferences	6	5	6	9	11	6	43
(8) 著書 Books	1	0	0	0	0	0	1
(9) 特許 Patents	0	1	0	0	0	0	1
(10) 招待講演 Invited Talks	0	0	0	0	0	2	2

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)-5) S. H. Kim, S. Hashi, K. Ishiyama, Y. Shiraishi, Y. Hayatus, M. Akiyama, Y. Saiki, T. Yambe, "Preliminary validation of a new magnetic wireless blood pump," Artificial Organs, Vol. 37, Issue 10, October, pp. 920-926 (2013). [IF: 2.111]

Abstract: In general, a blood pump must be small, have a simple configuration, and have sufficient hydrodynamic performance. Herein, we introduce new mechanisms for a wireless blood pump that is small and simple and provides wireless and battery-free operation. To achieve wireless and battery-free operation, we implement magnetic torque and force control methods that use two external drivers: an external coil and a permanent magnet with a DC-motor, respectively. Power harvesting can be used to drive an electronic circuit for wireless monitoring (the observation of the pump conditions and temperature) without the use of an internal battery. The power harvesting will be used as a power source to drive other electronic devices, such as various biosensors with their driving circuits. To have both a compact size and sufficient pumping capability, the fully magnetic impeller has five stages and each stage includes four backward-curved blades.The pump has total and inner volumes of 20 and 9.8 cc, respectively, and weighs 52 g.The pump produces a flow rate of approximately 8 L/min at 80 mm Hg and the power generator produces 0.3 W of electrical power at 120 W. The pump also produces a minimum flow rate of 1.5 L/min and a pressure of 30 mm Hg for circulation at a maximum distance of 7.5 cm.

International impact on both academic and social aspects: The pump that had been prototyped as a wireless drive type assisted artificial heart was clarified to meet the requirements from medical sites. In addition, we clarified that it was possible to perform wireless operation through the skin in animal experiments, and the required pressure and discharge rate could also be satisfied. Because it can be completely implanted, it is a small assisted artificial heart pump with a low risk of infection, and its practical application is expected as a technology that can contribute to the improvement of patients' QOL.

2)-1) J. Huang, K. Takashima, S. Hashi, Y. Kitamura, "IM3D: Magnetic Motion Tracking System for Dexterous 3D Interactions," ACM SIGGRAPH2014, Emerging Technologies, Article No. 12, (2014). August 10-14, Vancouver (Canada). [Demonstration, Acceptance rate: 20%]

Abstract: We propose IM3D, a novel magnetic motion tracking system with multiple tiny, identifiable, wireless, occlusion-free markers that provides reasonable accuracy, a reasonable update rate, and an appropriate working space for exterous 3D interaction. Though the principle IM3D has a ten-year history, IM3D is the first system to make it suitable for interactive applications, as we managed to find out an appropriate layout, and calculate the inverse problem through parallel programming to boost its speed, and so on. IM3D's features contribute to motion capture and interaction. Three novel applications that effectively utilize the features are built to demonstrate these

possibilities as follows. At first, a multi-finger application in which markers are fixed on users finger tips to enable finger-based manipulation with virtual objects. Second, the scene of tracking beetles in natural complex environment by fastening the markers on beetles horns. This can be applied in biology research because IM3D's battery-less markers make it possible to continuously track small creatures in natural environment for long time. Third, a method of interactive 3D clay modeling. Each of the ten markers is put into a small sphere case, which is covered with clay. The application allows users to create more flexible virtual 3D objects by manipulating the actual clay using our tiny and occlusion-free markers.

International impact on both academic and social aspects: The demonstration was received high evaluation from the large number of visitors gathered at the world's largest international conference in the field of computer graphics "Siggraph2014". This work is not only used as an interface for Computer Graphics, but it may be also usable for the archival of intangible cultural properties such as hand and craft, dance and so on, which has been attracting attention in recent years. In addition, in the medical and welfare fields, core technologies such as rehabilitation support are expected to be applied in a wide range of fields.

[2016-2018]

1-23) Y. Osaki, S. Hashi, S. Yabukami, H. Kanetaka, K. Ishiyama, "Wireless magnetic position-detection system with four excitation coils," IEEE Sensors Journal, Vol. 17, No. 14, pp. 4412-4419 (2017).

Abstract: For tracking position or motion of objects in small or shielded spaces, our wireless position-detection system using an LC resonant marker is considered to be effective. Generally, detection of the accurate position of the marker is difficult when reduction of the S/N ratio occurs due to the marker posture. To solve this problem, we propose a system with four excitation coils to generate four-directional magnetic fields whose components are different from each other. To evaluate this system, simulations and experiments were conducted for a single excitation coil and for four excitation coils. In the single excitation coil system, position detection was difficult for some postures of the LC marker due to the greatly reduced excitation efficiency of the marker. In contrast, in the four excitation coil system, the excitation strength of the marker was kept for every marker posture, and position detection was performed with high accuracy even when the marker was placed where the excitation was weakest. Therefore, it is possible to detect the position of the marker accurately regardless of its posture by using four excitation coils. By this improvement, our position-detection system is considered to be useful for tracking finger motion in some applications. [IF: 3.076]

International impact on both academic and social aspects: It is a breakthrough in this measurement system from the viewpoint of almost eliminating the magnetic occlusion that was a fundamental issue. Its application is highly expected as a high precision motion capture technology for fingers, especially in the human interaction field.

1-28) Y. Kubo, S. Hashi, H. Yokoi, K. Arai, K. Ishiyama, "Development of Strain and Vibration Sensor using Magnetostriction of Magnetic Thin Film," IEEJ Transactions on Sensors and Micromachines, Vol. 138, No. 4, pp. 153-158 (2018).

Abstract: We fabricated a strain sensor using the inverse-magnetostrictive effect of magnetoelastic thin films, and

applied it for vibration sensor. The sensor element consisted of 1 turn meander-patterned molybdenum (Mo) film as conductive layer and FeSiB magnetostrictive films that laminated a part of the meander. After annealing the element, the FeSiB films of the sensor element were subject to residual stress from Mo film and Si substrate, which induced a magnetic anisotropy of the FeSiB film via magnetoelastic coupling. From the impedance change of the element under compressive strain the sensor exhibited a gauge factor of 2,160 at a carrier frequency of 150MHz under compressive strain. In addition, a phase-difference detection circuit was fabricated to evaluate the element as a vibration sensor. When an edge load of 20g was attached to the element, the maximum signal of 288mV (45mV/deg.) correspond to vibration was obtained at the mechanical resonance frequency of 20.8Hz.

International impact on both academic and social aspects: The main topic of this work is that magnetic anisotropy induction method combining residual stress generated in thin film laminated structure after annealing and inverse magnetostrictive effect of magnetostrictive film and its applied for sensor devices. The achievements of realizing anisotropic control on a Si substrate according to the work have the potential of realizing various magnetic devices using magnetostrictive thin films, such as fusion with MEMS technology, and related fields the impact on the is considered to be very large.

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．

[2013-2015]

Ref. 4 -(2)-1)

◆ JST-SENTAN (Japan Science and Technology Agency, Development of advanced measurement and analysis systems) program, FY 2013-2016, Research title: "磁気 MEMS を利用した微小振動計測システムの開発,"
(K. Ishiyama, as a Principal Investigator, Total budget 82,880,525 Yen)

Our group carried out a research project that developing an new sensor device that forms an FeSiB amorphous magnetic thin film exhibiting strain detection characteristics found on its own on a MEMS cantilever and detects strain and vibration with high sensitivity and high accuracy. Elemental technologies development such as establishment of anisotropic control technology of magnetostrictive thin film, design and fabrication of three-layer structure cantilever, and development of circuit corresponding to phase detection method were realized. In addition, it was highly appreciated that the micro vibration measurement system which composed of these elemental technologies has been completed. In the future, further efforts for practical realization such as stability of sensing function, durability under severe environment, downsizing of system and cost reduction are strongly expected.

[2016-2018]

Ref. 4 -(2)-2)

◆ MIC (Ministry of Internal Affairs and Communications) project, FY 2015-2018, Research title: "Measurement and Countermeasure Methodologies to Deal with Broadening Unnecessary Radio Wave（不要電波の広帯域化に対応した電波環境改善技術の研究開発）,"
(K. Ishiyama, as a Principal Investigator, Total budget 104,316,369 Yen)

In this research project, we developed a measurement system using magnetic garnet for precisely identifying sources of leaked electromagnetic waves in order to prevent/reduce EMI concerned with the increase in density of LSI. Magneto-optical materials affect electromagnetic waves less than metal probes and optical measurements are advantageous for minimally invasive measurements of magnetic fields. To achieve a high resolution, we developed a stroboscopic method that employs short laser pulses. This method can measure a magnetic field in any phase because the laser pulses are synchronized with the magnetic field. With the advance of this research, it was found that multiply less invasive than the competing a conventional metal probe method, realizing spatial resolution of 5μm and detection sensitivity of 0.1mOe in a wide band including the GHz band. This measurement technology can be expected to be applied sufficiently as a technology for identifying a leakage magnetic field source of a circuit against the problem of EMI.