Junaid ur Rehman

Research Professor
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Education

- **Kyung Hee University, Yongin-si, Korea,** [QS Rank: 264] Sep. 2014 – Aug. 2019
  Doctor of Philosophy in Electronic Engineering
  Title: Dequantumization of Discrete Weyl Quantum Channels
  Advisor: Professor Hyundong Shin
- **National University of Sciences and Technology, Pakistan,** [QS Rank: 358] Sep. 2009 – Aug. 2013
  Bachelor of Engineering in Electrical Engineering

Research Interests

General research interest is quantum information processing for communication, metrology, and computing. Current research interests include machine learning for quantum information, quantum process tomography, and hybrid classical-quantum computing.

Honors and Awards

- **Best Paper Award** of the KICS Fall Conference, 2019
- **Best Paper Award** of the KICS Fall Conference, 2018
- **Best Paper Award** of the ICGHIT, 2018
- Postdoctoral Research Fellowship, Kyung Hee University, 2019 – 2020
- Doctoral Research Scholarship, BrainKorea21 Plus, 2014 – 2019
- Graduate Student Scholarship, Kyung Hee University, 2014 – 2019
- Undergraduate Merit Scholarship, National University of Sciences and Technology, Fall 2009

Experience

Work Experience

- **Kyung Hee University, Yongin-si, Korea** Jan. 2021 – Present
  BK21 Research Professor
  Department of Electronics and Information Convergence Engineering
  Teaching 6 credit hours per year
  Mentoring graduate students in their research in quantum information sciences
  Develop the "computing and communication convergence pillar" of
  the next generation communication and information convergence systems.

- **Korea Institute of Science & Technology, Korea** Sep. 2020 – Dec. 2020
  Postdoctoral Fellow
  Center for Quantum Information
  Achieved the experimental realization of hybrid (classical-quantum) algorithms for quantum chemistry.
  Developed the theory and experimental realizations of noise characterization and error mitigation methods for modern variational quantum algorithms.
  Designed theoretical and experimental techniques in (machine) learning for efficient characterization of quantum states.

- **Kyung Hee University, Yongin-si, Korea** Sep. 2019 – Aug. 2020
  Postdoctoral Fellow
  Department of Electronic Engineering
  Communications and Coding Theory Laboratory
  Led a team working on quantum entanglement theory and quantum metrology within the Communications and Coding Theory Laboratory.
  Mentored undergraduate and graduate students affiliated with the lab.
  Managed and coordinated different teams working on large-scale R&D projects including national research foundation (NRF)-funded projects and project in collaboration with national science foundation of China (NSFC).
- **Kyung Hee University, Yongin-si, Korea** Sep. 2014 – Aug. 2019
  Research Assistant
  Communications and Coding Theory Laboratory
  Provided technical and writing assistance in proposal writing for NRF projects.
  Conducted research on quantum information and quantum estimation theories in the scope of NRF project.
  Disseminated research findings in reputable journals and conferences.
  Co-supervised and mentored undergraduate and graduate students including three undergraduate theses.
  Led and supervised recruitment drives for new graduate students.
- **Kyung Hee University, Yongin-si, Korea** Mar. 2016 – Aug. 2019
  Teaching Assistant
  Department of Electronic Engineering
  Graduate courses: Fundamentals of Information Theory, Advanced Digital Communications, Fundamentals of Machine Learning, Research Ethics
  Undergraduate courses: Digital Communications
- **COMSATS University Islamabad, Pakistan** Dec. 2013 – Aug. 2014
  Research Associate
  Centre of Advanced Studies in Telecommunication
  Worked on the depth-image based 3D rendering and reduced-reference image quality assessment.

Teaching Experience

- **Kyung Hee University**
  Department of Electronics and Information Convergence Engineering
  - **EIC7036-00:** Convergence Future Communication Colloquium I
    Spring 2021
  - **EIC7044-00:** Quantum Communication Convergence
    Fall 2021
  - **EIC7033-00:** Convergence Future Communication Project II
    Fall 2021

- **Communications and Coding Theory Laboratory**
  Following are research group-level study sessions where I was involved in planning, teaching, and leading the discussion as a senior member.
  - **Group Study (Graduate Level):** Quantum Communications
    Spring, Fall 2016
  - **Group Study (Graduate Level):** Quantum Shannon Theory
    Spring, Fall 2017,
  - **Group Study (Graduate Level):** Quantum Detection and Estimation
    Spring 2018
  - **Group Study (Undergraduate and Graduate Level):** Introduction to Quantum Computing I
    Fall 2018
  - **Group Study (Undergraduate and Graduate Level):** Introduction to Quantum Computing II
    Spring 2019

Research Highlights

- **Experimental Quantum Technologies**: Participated in the implementation of state-of-the-art quantum computing, quantum metrology, and quantum detection & estimation protocols in photonic quantum systems. Specific contributions include:
  - **Variational Quantum Eigensolver on a Photonic Ququart**: Implemented the variational quantum eigensolver (VQE) for solving the ground-state energy of He–H^+ molecule on a photonic ququart. Devised an error mitigation scheme capable of estimation of ground state energies close to the chemical accuracy (1.6×10^{-3} Hartree) despite severe noise in one of the degrees of freedom of ququart. Identified the inherent noise resilience of the VQE for different noise types and proposed optimal mapping of Hamiltonian to different degrees of freedom of the available quantum system.
  - **Heisenberg-Limited Quantum Sensing**: Performed multiphase estimation using photonic qutrits. Derived the expected performance (Cramer-Rao bound) via different measurement configurations. Identified the parameter space where the standard quantum limit could be violated and demonstrated its experimental violation. Demonstrated the experimental superiority of unbalanced beamsplitting as compared to a balanced one for metrological purposes.
  - **Quantum Process Tomography**: Designed and experimentally implemented an efficient quantum process tomography scheme for optical channels on four-dimensional Hilbert space. The number of measurement settings in the proposed scheme scale linearly with the Hilbert space dimension. Demonstrated the scaling of mean square error in the number of channel uses to be comparable to those of entanglement-based methods.
- **Quantum Communication Networks:** The benefits of quantum phenomenon have spurred efforts to integrate quantum information processing techniques into future communication systems. Quantum communication is driven by fascinating physics and by promising applications—superdense coding, quantum teleportation, and quantum key distribution (QKD). It requires a new mix of competencies, from telecommunication engineering to theoretical physics, from theoretical computer science to mechanical and electronic engineering.
  - **Security in Quantum Key Distribution:** Developed a criterion for the integration of a control key for not only significantly improving the quantum key exchange rate but also providing security against the photon-number splitting (PNS) attack on the realistic weak coherent pulses.
  - **Deterministic Secure Quantum Communication:** Developed a two-way six-state deterministic secure quantum communication that is robust against losses. The protocol achieves deterministic communication even when integrated with the decoy state method. Analyzed a security of the protocol against the PNS attack in the absence of the decoy state method with two quantum direct communication protocols. Further characterized a success secure transmission probability of Eve when the protocol is used as a multiparty key distribution scheme.

- **Distributed Quantum Clock Network:** Developed a distributed quantum network that overcomes the limitations of a centralized network under local quantum phase-covariant decoherence. The proposed framework mitigates the effect of this decoherence and provides robust quantum clock synchronization against local oscillator frequency inaccuracy introduced due to external fields.

- **Characterizing Quantum Channels**: Characterized the entropic quantities of quantum channels that are relevant to classical communication over quantum channels. This characterization helps determine the most relevant noise model for an unknown channel and produces simple to compute bounds on the capacities of quantum channels. Specific contributions include:

  - **Asymmetric Unambiguous Discrimination of Quantum Channels:** Introduced a protocol for unambiguous discrimination of quantum channels without entanglement. Showed that the expensive resource of entanglement can be tradeoff to surrender the possibility of unconditional unambiguous discrimination of quantum channels. Showed the optimality of proposed protocol and worked out several examples of qubit channel models where unambiguous discrimination was previously considered impossible.
  - **Holevo Capacity of Discrete Weyl Channels:** Analyzed the achievable classical communication rates of a broad class of quantum channels, known as discrete Weyl channels (DWCs). Analysis showed that with certain input states, DWCs boil down to classical symmetric channels. This analysis produced tight lower bounds on the classical communication rates with separable inputs and arbitrary measurements (Holevo capacity). Proposed an upper bound to supplement the lower bound that is obtained by majorization theory and Schur concavity of von Neumann entropy. Finding the coincidence conditions of these two bounds allowed to propose special cases of DWCs whose exact Holevo capacity can be readily found.
  - **Estimating the Holevo Capacity of Discrete Weyl Channels:** Developed the protocol for estimating the lower bound on the Holevo capacity of an unknown but physically available DWC. The proposed protocol efficiently ($d+1$ measurement settings, for d-dimensional channel) estimates the lower bound without performing the complex (d^4 measurement settings) procedure of full process tomography.
  - **Discrete Weyl Channels with Markovian Memory:** Proved the general existence of the so-called transition behavior (of optimal signal states from product states to maximally entangled states as degree of memory is increased) for the whole class of DWCs, where the product states are optimal for the memoryless case. Developed two protocols, entanglement-assisted estimation (EAE) and entanglement-free estimation (EFE), for the estimation of degree of memory of DWCs. Showed that the proposed protocols also provide reliable estimates on the Holevo capacity of DWCs with Markovian memory, as a by-product.

- **Monogamy and Polygamy Relations of Multiqubit Entanglement:** Monogamy and polygamy relations of quantum entanglement characterize the sharing and distribution of entanglement in a multipartite system. Multiqubit entanglement can be characterized entirely with bipartite combinations by saturating the monogamy and polygamy inequalities. Specific contributions include:

  - **Tightening the Monogamy and Polygamy Inequalities:** Developed the technique based on the genetic algorithm (GA) to tighten the monogamy and polygamy inequalities. Fitted a shape (in terms of a mathematical expression) of the residual (the difference between both sides) of each inequality (monogamy and polygamy). Optimized key parameters of the residual expression to tighten the inequality using the GA.
  - **Unified Monogamy Relations of Multipartite Entanglement:** Extended the parameter range of Unified-(q,s) entanglement $\mathcal{U}_{q,s}$. Proved the squared $\mathcal{U}_{q,s}$-based monogamy relation for an arbitrary multiqubit mixed states. Constructed an efficient entanglement indicator based on the aforementioned monogamy relation. Established the αth power of $\mathcal{U}_{q,s}$ monogamy and polygamy inequalities for tripartite qubit states.

- **Quantum Metrology:** Quantum metrology utilizes quantum correlations to recast the measurement standards. Incorporation of high resolution and extreme precision in conventional measurements have contemporized the developments in health sector, aerospace communication and defense industry. Specific contributions include:

  - **Measurement-Based Quantum Correlation for Quantum Information Processing:** Proposed the notion of measurement-based quantum correlations (MbQCs). Proved that MbQCs exist more generally than entanglement and discord in deterministic quantum computation with a single qubit (DQC1) and assisted quantum state discrimination method proposed by Roa, Retamal and Alid-Vaccarezza (RRA scheme). Proposed a dimension witness based on the MbQCs for witnessing the dimension of an arbitrary quantum system. Showed that the dimension witness exercised via measurement-based quantum correlations benchmarks existing entanglement-based dimension witnesses in terms of scope and capabilities.
  - **Multiparameter Quantum Metrology with Realistic Measurements:** Computed the optimal sensitivity bounds in quantum multiparameter estimation scheme with multimode generalized $N00N$ states and realistic measurement settings. Showed that the quantum Fisher information might not be the correct metric to evaluate the achievable sensitivity when the experimental feasibility of the measurements is taken into account. Optimized the classical Fisher information as a function of input state parameters to provide the best achievable precision in practical setups.

Publications, Patents & Presentations

Journal Papers (Published/Accepted)

1. S. Hong, J. ur Rehman, Y.-S. Kim, Y.-W. Cho, S.-W. Lee, H. Jung, S. Moon, S.-W. Han, and H.-T. Lim, "Quantum enhanced multiple phase estimation with multi-mode $N00N$ states,", Accepted for publication in *Nature Communications*, 2021.

2. S. Ramadhani, J. ur Rehman, and H. Shin, "Quantum error mitigation for quantum state tomography,", Accepted for publication in *IEEE Access*, 2021.

3. J. ur Rehman and H. Shin, "Entanglement-free parameter estimation of generalized Pauli Channels," *Quantum*, 5:490, Jul. 2021.

4. U. Khalid, J. ur Rehman, and H. Shin, "Metrologically resourceful multipartite entanglement under quantum many-body effects," *Quantum Sci. Technol.*, 6:025007, Jan. 2021.

5. J. ur Rehman, A. Farooq, and H. Shin, "Discrete Weyl channels with Markovian memory," *IEEE J. Sel. Area. Commun.*, vol. 38, no. 3, pp. 413-426, Mar. 2020.

6. M. A. Ullah, J. ur Rehman, and H. Shin, "Quantum frequency synchronization of distant clock oscillators," *Quantum Inf. Process.*, 19:144, Mar. 2020.

7. U. Khalid, J. ur Rehman, and H. Shin, "Measurement-based quantum correlations for quantum information processing," *Sci. Rep.*, 10:2443, Feb. 2020.

8. A. Khan, J. ur Rehman, K. Wang, and H. Shin, "Unified monogamy relations of multipartite entanglement," *Sci. Rep.*, 9:16419, Nov. 2019.

9. J. ur Rehman and H. Shin, "Purity-based continuity bounds for von Neumann entropy," *Sci. Rep.*, 9:13912, Sep. 2019.

10. J. ur Rehman, Y. Jeong, and H. Shin, "Directly estimating the Holevo capacity of discrete Weyl channels," *Phys. Rev. A*, 99:042312, Apr. 2019.

11. A. Farooq, J. ur Rehman, Y. Jeong, J. S. Kim, and H. Shin, "Tightening monogamy and polygamy inequalities of multiqubit entanglement," *Sci. Rep.*, 9:3314, Mar. 2019.

12. J. ur Rehman, Y. Jeong, J. S. Kim, and H. Shin, "Holevo capacity of discrete Weyl channels," *Sci. Rep.*, 8:17457, Nov. 2018.

13. J. ur Rehman, A. Farooq, Y. Jeong, and H. Shin, "Quantum channel discrimination without entanglement," *Quantum Inf. Process.*, 17:271, Oct. 2018.

14. T. Bashir, I. Usman, S. Khan, and J. ur Rehman, "Intelligent reorganized discrete cosine trans- form for reduced reference image quality assessment," *Turk. J. Elec. Eng. & Comp. Sci.*, vol. 25, no. 4, p. 2660, Jul. 2017.

15. S. Qaisar, J. ur Rehman, Y. Jeong, and H. Shin, "Practical deterministic secure quantum communication in a lossy channel," *Prog. Theor. Exp. Phys*, vol. 2017, no. 4, pp. 1–12, Apr. 2017.

16. J. ur Rehman, S. Qaisar, Y. Jeong, and H. Shin, "Security of a control key in quantum key distribution," *Modern Physics Letters B*, vol. 31, no. 11, pp. 1–12, Apr. 2017.

17. T. Bashir, I. Usman, and J. ur Rehman, "Secure digital watermarking using optimized improved spread spectrum and BCH coding for DIBR 3D-TV system," *Multimedia Tools and Applications*, vol. 75, no. 13, pp. 7697–7713, Jul. 2016.

Refereed Conference Proceedings

1. A. Farooq, J. ur Rehman, Y. Jeong, and H. Shin, "Polygamy Relations for Higher Dimensional Quantum Systems," in *Proc. Joint Conference on Communications and Information (JCCI 2021)*, Korea, Feb. 2021.

2. A. Farooq, J. ur Rehman, and H. Shin, "Distribution of Entanglement in Multipartite Qubit States," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, Feb. 2021.

3. M. A. Ullah, J. ur Rehman, and H. Shin, "Photon Dynamics in Counterfactual Quantum Communication," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, Feb. 2021.

4. U Khalid, J. ur Rehman, and H. Shin, "Quantum Correlations in Single Qubit Metrology," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, Feb. 2021.

5. A Khan, J. ur Rehman, and H. Shin, "Upper Bound of Renyi-a Entanglement for Multipartite PCS States," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, Feb. 2021.

6. S. Ramadhani, J. ur Rehman, K. Lee, and H. Shin, "Quantum State Tomography with the Indefinite Causal Order," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, Feb. 2021.

7. S. M. Kazim, J. ur Rehman, K. Lee, and H. Shin, "Adaptive Optimal Basis Tomography for Qubits," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, Feb. 2021.

8. J. ur Rehman, D. Lee, J. Lee, H. T. Lim, Y. W. Cho, and Y. S. Kim, "Variational quantum eigensolver using a photonic ququart," in *Optical Society of Korea (OSK) Photonics Conference 2020*, Korea, Nov. 2020.

9. J. ur Rehman and H. Shin, "Optimal parameter estimation of noisy Pauli channels," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

10. M. A. Ullah, J. ur Rehman, and H. Shin, "On the usefulness of ancilla-assisted entanglement for metrology," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

11. N. Paing, F. Zaman, J. ur Rehman, and H. Shin, "Counterfactual universal logic gates," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

12. S. Ramadhani, J. ur Rehman, and H. Shin, "Entanglement protection in quantum channels with memory," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

13. S. M. Kazim, A. Farooq, J. ur Rehman, and H. Shin, "Applied Bayesian qubit state tomography," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

14. K. Kwon, F. Zaman, J. ur Rehman, and H. Shin, "Classical simulation of Shor's algorithm," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

15. S. Yun, F. Zaman, J. ur Rehman, and H. Shin, "Bell's inequality violation on MATLAB," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Korea, Aug. 2020.

16. S. Yun, K. Kwon, J. ur Rehman, F. Zaman, and H. Shin, "Quantum duplex coding for classical information on IBM quantum devices," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, Nov. 2019. **(Best Paper Award)**

17. A. Farooq, J. ur Rehman, and H. Shin, "Characterization of multiqubit-state entanglement," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, Nov. 2019.

18. A. Khan, J. ur Rehman, and H. Shin, "General polygamy relation of Rényi-α entanglement for tripartite systems," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, Nov. 2019.

19. U. Khalid, J. ur Rehman, and H. Shin, "Dimensional analysis of bipartite qudits for mixed-state metrology," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, Nov. 2019.

20. J. ur Rehman, Y. Jeong, and H. Shin, "Conditional dequantization of quantum channels," in *Proc. Joint Conference on Communications and Information (JCCI 2019)*, Korea, May 2019.

21. J. ur Rehman, Y. Jeong, and H. Shin, "Continuity bounds of von Neumann entropy," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, Nov. 2018.

22. J. ur Rehman, Y. Jeong, and H. Shin, "Asymmetric unambiguous discrimination of quantum channels," in *Proc. International Conference on Green and Human Information Technology (ICGHIT 2018)*,Chiang Mai, Thailand, Jan. 31–Feb. 2, 2018, pp. 10–14. **(Best Paper Award)**

23. J. ur Rehman, Y. Jeong, and H. Shin, "Classical data locking in quantum states," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, Nov. 2017. **(Best Paper Award)**

24. J. ur Rehman, Y. Jeong, and H. Shin, "Quantum key distribution with a control key," in *Proc. International Symposium on Wireless Communication Systems (ISWCS 2017)*, Bologna, Italy, Aug. 28–31, 2017, pp. 112–116.

25. J. ur Rehman, Y. Jeong, and H. Shin, "Classical capacity of composite quantum channels," in *Proc. IEEE VTS Asia Pacific Wireless Communications Symposium (APWCS 2017)*, Incheon, Korea, Aug. 23–25, 2017, pp. 197–201.

26. J. ur Rehman, S. Qaisar, Y. Jeong, and H. Shin, "One basis quantum key distribution," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, 2016.

27. S. Qaisar, J. ur Rehman, Y. Jeong, and H. Shin, "Distributed multiparty quantum key distribution," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, 2016.

28. J. ur Rehman, S. Qaisar, Y. Jeong, and H. Shin, "Multi-party quantum key distribution," in *Proc. Joint Conference on Communications and Information (JCCI 2016)*, Korea, Apr. 2016.

29. S. Qaisar, J. ur Rehman, Y. Jeong, and H. Shin, "Low-power operating quantum key distribution," in *Proc. Joint Conference on Communications and Information (JCCI 2016)*, Korea, Apr. 2016.

30. J. ur Rehman, Y. Jeong, and H. Shin, "Finite-key analysis of BB84 and MDI quantum key distributions," in *Proc. Korea Information and Communications Society (KICS) Winter Conference*, Korea, 2016.

31. J. ur Rehman, Y. Jeong, and H. Shin, "Asymptotic Rényi entropy," in *Proc. Korea Information and Communications Society (KICS) Fall Conference*, Korea, 2015, pp. 11–12.

32. J. ur Rehman, Y. Jeong, and H. Shin, "A BB84 variant for a high key exchange rate," in *Proc. 1st Conference on Next Generation Quantum Communication Technologies*, Chuncheon, Korea, Nov. 2015, pp. 8–9.

33. J. ur Rehman, J. S. Ju, J. W. Park, J. W. Lee, Y. Jeong, and H. Shin, "Measurements for multipath fading using USRP," in *Proc. Korea Information and Communications Society (KICS) Summer Conference*, Jeju, Korea, June 2015, pp. 469–470.

Patents

1. H. Shin, J. ur Rehman, A. Khan, and A. Farooq, "Method of Distributing Quantum Entanglement and Quantum Communication System Thereof," Korea Patent 10-2237183, Apr. 01, 2021.

2. H. Shin, J. ur Rehman, and M. A. Ullah, "Quantum Synchronization Method Without Shared Phase Reference and Quantum Communication System Thereof," Korea Patent 10-2231135, Mar. 17, 2021.

3. H. Shin, Y. Jeong, and J. ur Rehman "Quantum Channel Capacity Estimation Method and Quantum Communication System Thereof," Korea Patent 10-2231130, Mar. 17, 2021.

4. H. Shin, J. ur Rehman, and U. Khalid, "Quantum Measurement Method Using Perturbation Sensitivity and Quantum System Using Thereof," Korea Patent 10-2211060, Jan. 27, 2021.

5. H. Shin, J. ur Rehman, and A. Khan, "Method of Finding Entanglement Constraint in Multiqubit System and Quantum Communication System Thereof," Korea Patent 10-2203527, Jan. 11, 2021.

6. H. Shin, J. ur Rehman, and A. Farooq, "Method of distributing quantum entanglement and quantum communication system," Korea Patent 10-2158777, Sep. 16, 2020.

7. H. Shin, Y. Jeong, J. Kim, A. Farooq, and J. ur Rehman, "Method of distributing optimally quantum entanglement and quantum communication system," Korea Patent 10-2122799, Jun. 09, 2020.

8. H. Shin, Y. Jeong, and J. ur Rehman, " Method of securing quantum information and system thereof," Korea Patent 10-2017835, Aug. 28, 2019.

9. H. Shin, S. Qaisar, Y. Jeong, and J. ur Rehman, "Method and device for deterministic secure quantum communication," Korea Patent 10-1965229, Mar. 25, 2019.

10. H. Shin, J. ur Rehman, S. Qaisar, and Y. Jeong, "Method and device of performing quantum key distribution (QKD) among plurality of devices," Korea Patent 10-1924100, Nov. 26, 2018.

11. H. Shin, J. ur Rehman, S. Qaisar, and Y. Jeong, "Method of distributing key for multi-party in quantum communication, method of performing quantum communication using the same and quantum communication system performing the same," Korea Patent 10-1836947, Mar. 5, 2018.

12. H. Shin, S. Qaisar, J. ur Rehman, and Y. Jeong, "Method of distributing key with low-power in quantum communication, method of performing quantum communication using the same and quantum communication for performing the same," Korea Patent 10-1826065, Jan. 31, 2018.

13. H. Shin, J. ur Rehman, and Y. Jeong, "Method of distributing key in quantum communication, method of preforming quantum communication using the same and quantum communication system performing the same," Korea Patent 10-1808544, Dec. 7, 2017.

Theses

1. J. ur Rehman, "Dequantumization of discrete Weyl quantum channels," Ph.D. dissertation, Department of Electronic Engineering, Kyung Hee University, Yongin-si, Korea, Aug. 2019, Thesis Advisor: Professor Hyundong Shin.
2. J. ur Rehman, "Multivariate PID controller with HMI," Bachelor's thesis, Department of Electrical Engineering, National University of Sciences and Technology, Islamabad, Pakistan, Aug. 2013, Thesis Advisor: Professor Taosif Iqbal.

Professional & Scholarly Activities

Professional Reviews

- Session Chair in IEEE VEHICULAR TECHNOLOGY SOCIETY ASIA PACIFIC WIRELESS COMMUNICATIONS SYMPOSIUM (VTS APWCS 2018)
- Reviewer of IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS
- Reviewer of IEEE ACCESS
- Reviewer of IEEE INTERNATIONAL CONFERENCE ON WIRELESS AND MOBILE COMPUTING (WiMob 2015, 2016, 2017)
- Reviewer of IEEE GLOBAL COMMUNICATIONS CONFERENCE (Globecom 2015, 2016, 2017, 2018)
- Reviewer of IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS (ICC 2016, 2017, 2018)
- Reviewer of IEEE VEHICULAR TECHNOLOGY SOCIETY ASIA PACIFIC WIRELESS COMMUNICATIONS SYMPOSIUM (VTS APWCS 2016, 2017, 2018)
- Reviewer of SYMPOSIUM ON ASSISTIVE TECHNOLOGIES FOR THE DIFFERENTLY ABLED (ATDA 2017)
- Reviewer of IEEE ANNUAL INTERNATIONAL SYMPOSIUM ON PERSONAL, INDOOR, AND MOBILE RADIO COMMUNICATIONS (PIMRC 2017)

Professional References

Available upon request.