Research Prospects in Electrical Engineering and Informatics at Hasanuddin University: Trends and Challenges

[#]E. Palantei[1], R.S. Sadjad[2], M. Anshar[3], Indrabayu A.[4], N.N.R.A. Mokobombang[5], A. Suyuti[6], Z. Zainuddin[7], Z. Muslimin[8], and N.Harun[9]
[1-9] Electrical Engineering Department, Faculty of Engineering, Hasanuddin University (UNHAS)
Jl. Perintis Kemerdekaan Km.10 Tamalanrea, Makassar
[1] elyas_palantei@unhas.ac.id, [2] rhiza@unhas.ac.id, [3]anshar@unhas.ac.id, [4]indrabayu@unhas.ac.id, [5]novy@unhas,.ac.id, [6]ansar_suyuti@unhas.ac.id, [7]zahirz2930@yahoo.co.id, [8]zaenab_muslimin@yahoo.com and [9]n_harun@unhas.ac.id

1. Introduction

The practical operation of universities in the 21st century is majority based on the hierarchies of disciplinary area of study. The social values at the surrounding environment are significantly influence to force the change on the structure of disciplinary areas mainly in the knowledge production and the dissemination of both research and teaching activities [1]. Regarding the trends of future development at the most of biggest and popular universities (public and private) in Indonesia for the last decade have shown the similar outlook. In terms of the teaching and the research efforts to improve their accreditation and the acceptance of their alumni not only in the industry sectors but also the government and private sectors, many universities introspects themselves and adjust the curricula to link and match with the actual needs of those sectors.

Recently, the Department of Electrical Engineering, as a part of the structure of the Engineering Field of Study according [1] terms, has two study programs i.e. (1) Electrical Engineering (2) Informatics Engineering. The last mentioned study program was established at about 2008. It is relatively new area of study the Department has. Thus, there has no exact development planning fulfilled yet. Meanwhile, the Electrical Engineering study program at the moment has 3 Sub-Study Programs. This is including

1. ***Energy and Electrical Power Engineering (EEPE)***. The oldest sub study program the Department of Electrical Engineering has. It established since 1963.
2. ***Telecommunication Engineering and Information Systems***. This study program was initially established in 1980. Together with the study fields of Electronic Engineering it formed the sub study program so-called ***Telecommunication and Electronic Engineering***. Nowadays, its name changes to ***Telecommunication and Information Engineering*** (TIE) after the Electronic Engineering was expanded and separated.
3. ***Computer, Control and Electronic Engineering***. This study program was established since 1995. Even though, this sub-study program is relatively young, however it has crucial roles for linking all the areas of study within the department.

By quoting the vision and mission of the Electrical Engineering Department adopted from R. S. Sadjad ***et al.*** [2], it is clearly seen that the future development of the Electrical Engineering and Informatics-study programs are directed to achieve the status as one of the leading engineering education institution at both the national and international level. This purpose is going to achieve by strengthening the good tradition and quality on producing the professional graduates (enhancing the quality of the teaching tools such as software, hardware and brainware). This great obsession is followed by proactively encouraging and supporting all the faculty members to involve in many advanced research and development (R&D) of the related technology.

Teaching, research, and artistic activities are central to Hasanuddin University vision and mission. Over the next two to five years, indeed, the electrical engineering and informatics study program must continue to foster excellence in those areas by planning and implementing the creative and innovative activities to compete with other centre of excellence institution/ world class university partner. Some information presented in this paper is one method of how to promote the progress of R&D activities conducted at the Electrical Engineering Department for a certain period of time. For the sake of the systematic and coherence of the manuscript structure, the topics of discussion will include all the R&D activities involved on the three sub-study programs mentioned previously. These will be extensively explained on the following sections.

2. Recent Study on Energy and Electrical Power Engineering

There are various research activities the Electrical Engineering Department has implemented. Through the large financial support provided by the government institutions such as PT.PLN and the General Directorate of Higher Education, Ministry of National Education, several research activities have being developed and shown the good progress for further development. Some of the potential R&D issues are including the following such as Renewable Energy Study, Optimisation Techniques (e.g. Costs, Operational and Maintenance), Study on Power System Stability, and New Innovation on Isolator Materials. However, the extensive discussion of R&D progress in this section will be limited only on the renewable energy study.

The research project, on the development of the electric power generation to utilize the available renewable energy on a remote area, is under development at the Centre of Renewable Energy Study (CRES)-recalled ***Pusat Kajian Energi Terbarukan*** **(PKET)**, Electrical Engineering Department, Hasanuddin University. The research is very important for the sustainability of the electric power supply to all people living at the isolated region such as highlander, islanders and remote villagers throughout South Sulawesi province. The main goal of the research is to assembly a prototype of the low cost, stable, and easy of installation, operational and maintenance of the power generation system. This activity is a very urgent need especially on the actual situation where the world life facing the energy crisis for several times, even in the future. The research on this area was initially introduced at the Electrical Engineering Department since *N. Harun* [3] successfully completed his Doctoral degree from the Postgraduate Faculty, Hasanuddin University in the collaboration with Technische Universitat (TU) Berlin. The extension of this study was reported in [4]. A number of the similar researches have been consistently developed after this time.

A. Suyuti ***et al.*** [5] elaborated some factors that cause the electricity crisis in South Sulawesi province such as: ***firstly***, mismatching between the improvement of the electrical power supply capacity (which is only 3.5 % per year) and power consumption demand (which is about 7% per year). There is a trend that the increasing of power consumption is not linear comparing to the availability of the energy power supply; ***secondly***, there is no development of new power generation station for along period that also become the main cause of the instability of power supply. To provide sufficient supply the development of new power station is compulsory; ***thirdly***, on several areas at South Sulawesi province some power generation systems are relied on the fuel energy, for instance PLTD Suppa using diesel machines to generate the electricity power. The fuel energy is unrenewable resources. It has limited availability in the future.

Considering those crucial problems, some researchers collaborated within CRES group are conducting the studies on the development of hybrid power generation system which optimally utilize the availability of the local renewable energy resources. Recently, the study of hybrid power generation prototype is capable to generate the electricity capacity of less than 1,5 k Watt. This hybrid power system combined two single-power generators utilizing the local available energy resources such as wind and hydro.

The designed hybrid power generator is going to be expanded to involve other renewable energy resources such as: *solar*, *thermal*, and *biofuels*. Research prospects on this area are playing the important role as one solution to overcome the crisis on the electricity generation, particularly, in a remote area at South Sulawesi Province. The importance of the research is not only stimulated by the limited availability of the fuels energy to generate the sufficient electricity supplies to the local people but also forced by the fact that our environment provide us the unlimited and sustainable energy resources, so-called the *renewable energy resources*. The capacity of the electric power that can be potentially generated from this kind of the energy resources throughout Indonesian archipelagos is depicted in Table 1.

Table 1: Profiles of the renewable energy resources in Indonesia (Year of 2000) [6-8]

Energy Type	Potential	Equivalent/ Specific Power	Installed Capacity (MW)	Percentage (%)
Hydro	845 10^6 BOE	75.67 GW	3854	5
Geothermal	219 10^6 BOE	19.66 GW	807	4
Mini / Microhydro		458.75 MW	54	12
Biomass		49.81 GW	302.4	0.6
Solar Energy (PV)	4.8 kWh/m^2/day	1203 TW	5	4 10^{-7}
Wind Energy	3-6 m/s	9287 MW	0.5	5 10^{-3}
Biogas		684.83 MW		

To implement the designed hybrid power generation system, our research activities are divided into three main sub-activities including ***field surveys, prototyping*** and ***installation of hybrid power generation system*** and ***field-testing (testbed system)***. It is expected that the research will gain a great success to build the prototype of the renewable hybrid power generation that will be capable for sufficiently supplying the electric power to the people of particular isolated area.

3. Telecommunication and Information Engineering: Current Studies and Future Directions

As the growth of research in telecommunication and the need of interdisciplinary among study programs, the future of TIE program would be divided into three major programs i.e. ***Fixed and Mobile Telecommunication, Multimedia Signal Processing, and Multimedia Communication Network.*** The structure of TIE disciplinary area of study is described in Figure 1.

Wireless Telecommunication

The trend will be mainly on the use of high frequency due to the unlimited and the wide spectra available at that frequency range and beyond. The main constraint in wireless study is the bandwidth and one of the easiest ways to increase bandwidth by shifting the system to higher frequency. However, not only shifting to higher frequency give benefits of bandwidth but also degrading effect particularly fading in wireless. The significant problems while working at the higher frequency is the path loss effect. The higher the frequency operation the bigger the path loss occurred. Currently TIE also working on WiMAX (2 – 11 GHz) implementation in Indonesia, particularly in modelling and fabricating various antennas applicable for wireless communication

systems. The great potential R&D in this topic is the design and manufacturing a number of smart antennas capable to perform many tasks such as electronic beam-pattern steering, polarisation switching and frequency tuneable [9]. Some researches also conducted on the use of beneficial characteristic of QoS in WiMAX.

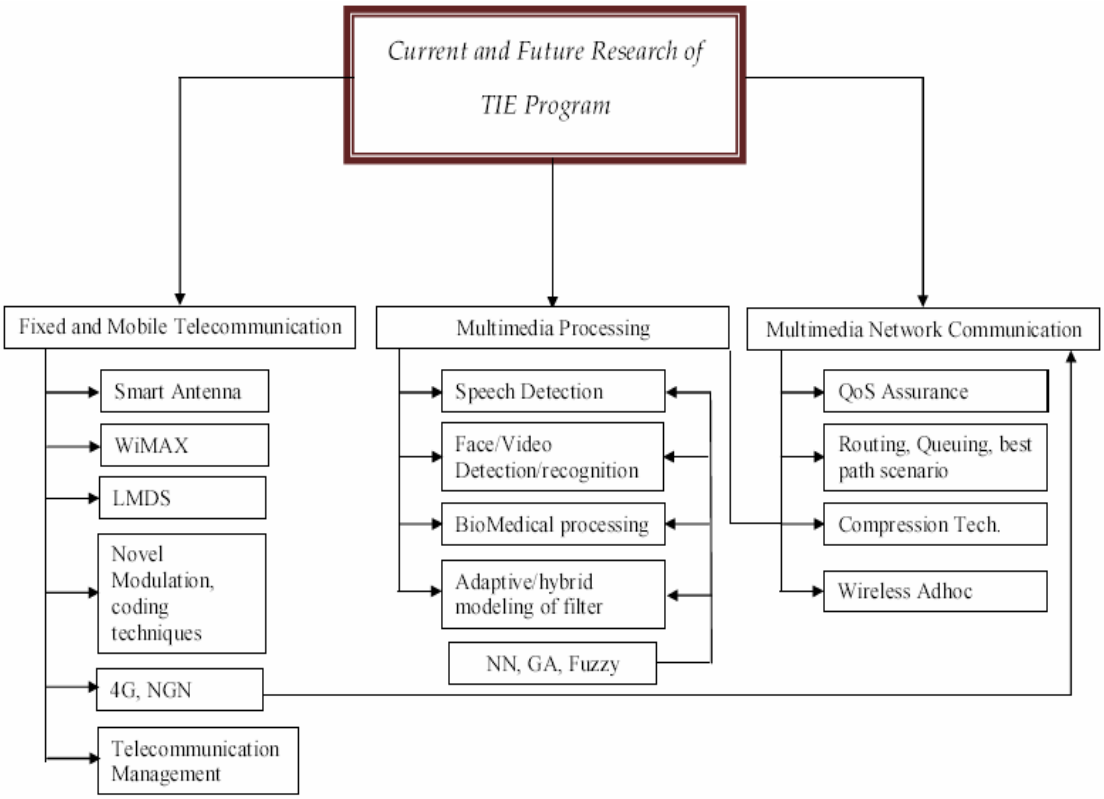

Figure 1: The structure of TIE disciplinary area of study

Local to Multipoint Distribution System (LMDS) a system that work at 18 – 32 GHz. Current research still investigating on how to implement the system in Indonesia. Rain fading becomes the main problem of the LMDS system and unfortunately Indonesia is a tropical country with high rain fall rate. Research on channel coding, adaptive modulation, diversity techniques, MIMO, and so on and so forth will be crucial to the LMDS system.

4G and NGN (Next Generation Network) are two topics that will have many attentions among wireless researcher, especially mobile cellular. The change on the paradigm occurs which mobile users are now distributed with an IP-based system. The interesting study of this area lies on the future issues of the reconfigurable, heterogeneous, and intelligent wireless communication systems.

Multimedia Signal Processing

In principle, the signal processing study in telecommunication area are commonly focusing on watermarking, steganography, multimedia recognition (speech, image, video) and last but not least is how to cope with the traditional and crucial problems, such as noise, fading and interference, encountered in the network.

It is inevitable situation where signal processing is not matter only to telecommunication but also on other focus of study like medical, geology, etc. The finding of wavelet transformation has pushed the researchers to investigate it in medical purposes as the tool for supported diagnoses.

Multimedia Network Communication

Nowadays, people tend to use multimedia in telecommunication. A voice only based conversation will be left behind in the next telecommunication era. Hence, Research in Multimedia Communication is also interesting area that TIE Study program will work on.

Current research working on finding best method in routing, queuing of packet in buffering are conducted in order to achieve a better performance of Multimedia Network i.e. throughput, latency, and jitter. Coding and compression techniques are also crucial in this area which the need of smaller size of data during transmission that can be transformed back into bigger data at the end. Wireless Ad-hoc is also current topic which TIE program study in. Our Research mainly focuses in the application of routing and identifying object (user) location. In the future, the application of wireless ad-hoc will be on larger enterprise like how to apply it in vehicle, boats and other vehicular objects.

The Importance of Telecommunication Management: *Vision and Reality*

With the incredible growth in telecommunications technologies, telecommunication management has become increasingly important in the digital world. Telecommunications penetration, digital divide and the ranging of telecommunication technology such as fixed line voice and data services, mobile voice and data services, communication usage and spending of SMEs and IP VPN have introduced the important of Telecommunication Management.

There are various types of R&D activities in the telecommunication management area of study currently under planning stage in the Department of Electrical Engineering, UNHAS. In conjunction to the above development trends, the following research aspects are the main concern of a researcher staffs group to be implemented in the near future, such as:

1. Case studies in telecommunications planning and management in several telecommunication operator companies. This study concerns on how services can mitigate imbalance penetration and digital divide among Indonesia islands.
2. Challenges and opportunities in telecommunications technologies and applications such as Telecommunication Management Network (TMN).
3. Network Management (IP, WDM, 3G/4G, Wireless, Ad-hoc/Mesh, Sensor, Home, Access, NGN, Grid)
4. Management System Development (enterprise network, public network, dedicated network, VPN, internet, intranet, mobile network, access network, multimedia network, customer network, VoIP network and integrated management)
5. Modeling, designing, deploying, and using networked systems.
6. Effects of regulation on telecommunications products and services.
7. Issues in Indonesia telecommunications planning and management. Such as pay-TV, submarine cable serving, broadband services and satellite serving Indonesia.
8. Telecommunications architecture such as 3.5 G, WiMAX and LTE 3GPP architecture models.
9. All other related issues in how the telecommunications planning and management can minimize telecommunication issues in Indonesia.

As wireless and wired networks complement, as for example, by a growing range of mobile devices are having a tremendous impact on the ways companies serve customers and run their operations. In conjunction with the above R&D themes, consider how TTI management, lecturer, researches and students helping define and advance the plan over the next two to five years. TTI team proactively work with Department, Faculty, University and others to gauge the advancement of the research activities accommodating all factors by which excellence can be monitored in each area.

4. Advanced Research in Computer, Control and Electronic Engineering

The third sub-study program (or "concentration") in the Electrical Engineering Study Program is the Computer, Control and Electronic Engineering sub-study program. The focus of this sub-study program is the study on the **COMPUTER**, which is basically a software driven system built over **electronic** devices internally, and – in the electrical engineering world – is an essential part of a modern **control system** externally. Three laboratories support this sub-study program accordingly: (1) **Computer Laboratory,** (2) **Electronic Devices Laboratory** and (3) **Control Systems and Instrumentation Laboratory**.

The leading laboratory among the three is the Computer Laboratory where students learn the architecture of computer systems and the software engineering through various basic and intermediate level of computer research laboratory courses. The future of this laboratory is directed toward 2 (two) central themes, namely: (1) parallel processing and online feedback directed optimization for High Performance Computing (HPC) and (2) computer network architecture and systems.

The Electronic Devices Laboratory is mainly focusing on the development of various electronic devices, circuits and systems, from the printed circuit board level down to the systems on chip level. The main themes are the digital telecommunication electronics and intelligent sensors. The research activities in this laboratory also cover the software development of various circuit design tools, from the system level, printed circuit board level, up to VLSI design.

The third laboratory to support this sub-study program is the Control Systems and Instrumentation Laboratory. The advanced research programs in this area are directed around 2 (two) central themes, namely: (1) industrial automation and robotics and (2) process control technology. Both themes, especially the later, are expected to enhance the linkage between the academic world and the industrial world in the surrounding region of east Indonesia.

Current advancement in automation and robotics is the emergence of AI robotics which occurred in a few decades back with the innovation of Artificial Intelligence (AI) while in process control, sensors typically, have played a predominant role in a success of process control and the sensor technology itself is one of the most progressive and fruitful field of research.

4.1 Introduction to AI Robotics

Since the appearance of Artificial Intelligence (AI) for the first time which was coined by John McCarthy, the study of AI has become a fruitful research area. Through vast achievement of this area, humans life have significantly benefit from. Let say, in robotics field, the implementation AI has been greatly improved and this area latter known as Artificial Intelligent Robotics (AI Robotics).

Currently, AI Robotics is one of research field which has forged the advancement of robot technology. However, in particular Indonesia region, there is a very limited research effort dedicated to AI robotics. Hence, through this paper, we encourage more research effort emerges in this area. Implementation of AI Robotics typically focuses on autonomy aspect as the essential element of an intelligent robot. As an introduction, this paper briefly describes the so-called robotic paradigms.

In the book of Introduction to AI Robotics by Murphy, R.R., the author describes the three commonly accepted primitive of robotics which are sensing, planning and actions. These three primitives play a major role in the functionality of robots and latter, the robotic paradigms are strongly link to each primitive. The first is hierarchical paradigm in which the functionality of

robots refers to the primitives of robotics in sequence. In other words, the robot senses the world, makes the plan for the next action, and then executes (sense-plan-act). The second one is reactive paradigm. In this paradigm, functionality of the robot is organized based on the sense-then-act type. No *plan* entity is involved, only sensor information will directly execute an action. The last paradigm is hybrid deliberative/reactive which is emerged in the 1990's. The organization of this type is that the functionality of robot is firstly initiated with plan and then followed by the sense-then-act paradigm. In other words, the plan is carried out at first step followed by the sensing and acting together. These three paradigms and primitives play a major role as one fundamental element of AI Robotics. One of research activities which have been developed in this area of study is illustrated in Figure 2.

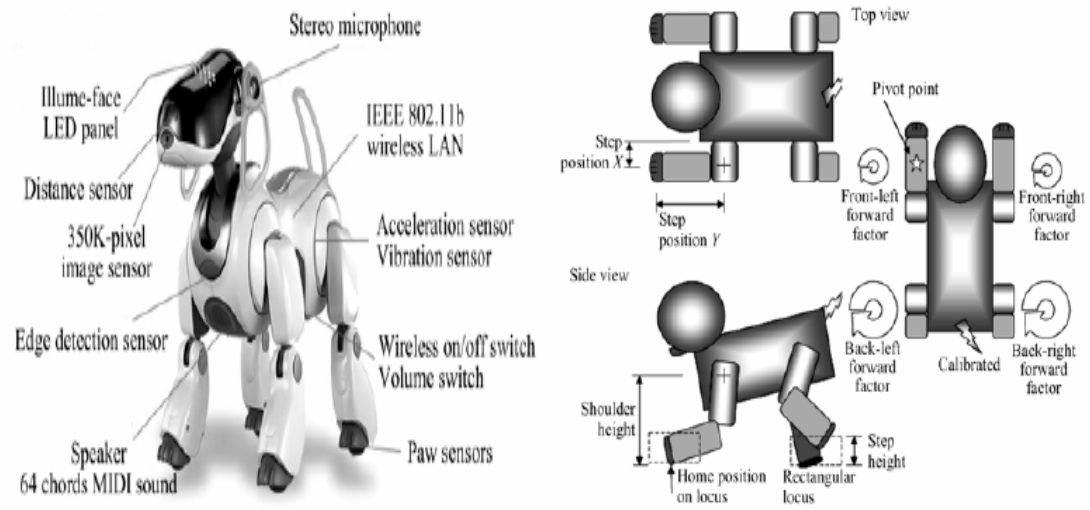

Figure 2: One scenario of R&D in AI Robotics [Adopted from [10]]

4.2 Sensor Networks

In line with the global trends on the development of the sensor technology, the sensor network is also the main concern of the research activity conducted by a number of staffs and students in the Electrical Engineering Department. There are various methods to implement the sensor system [11]. These are including the ad-hoc and dynamic methods. Two significant advancements in the sensor networks study within the department have been investigated in [12-13], respectively. In general, researches on the application of the wireless sensor network for the environments monitoring such as ***flooding estimation*** and ***landslide sensing***. It is expected more researches in this area will developed in the near future.

5. Concluding Remarks

Despite the different establishment time amongst the sub-study program integrated in the Electrical and Informatics Engineering Study Program, the academic and research activities within the Department of Electrical Engineering are continuously evolving and showing-up their existences and quality not only at the national level but also globally. With the return of several faculty members the department belongs, after finishing their PhD study abroad i.e. one PhD candidate in Germany, nine PhD candidates in Japan, five PhD candidates in Australia, one PhD candidate in Malaysia, and 5 PhD students in a number of popular public universities in Indonesia, will become the potential trigger to the fast and modern developments of many areas of research including in the future research route maps within the department.

In order to reward research innovations and enhancing the quality of it outcomes, including

those that arise through team-teaching and researcher and students, the following prompt actions should be carried out. These are including:

- developing the existing research programs;
- partnering in innovative ways with the governments, industry, and others in developing a knowledge-based emerging telecommunication technology
- maximizing benefits and potential skills from the Electrical Engineering Department resources;
- expanding interdisciplinary research and development programs within the University, and with researchers outside the University;
- maintaining the flexibility to respond research opportunities;
- maximizing the benefits of research through effective technology and knowledge transfer within lecturer; and
- Expanding undergraduate and graduate programs with research program strengths.

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