

State University of Makassar

**INTERNATIONAL CONFERENCE ON MATHEMATICS,
SCIENCES, TECHNOLOGY, EDUCATION
AND THEIR APPLICATIONS**

*"Recent Research and Issues in
Mathematics, Sciences, Technology, Education
and their Applications"*

**PROCEEDINGS
ICMSTEA 2014**

Makassar, August 20-21, 2014

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**INTERNATIONAL CONFERENCE ON MATHEMATICS, SCIENCES,
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WELCOME SPEECH

Forewords from the Head of Committee

Assalamu'alaykum wa Rahmatullahi wa Barakatuh

First, I want to give our welcome to all the delegates, speakers, and participants coming today. Welcome to State University of Makassar, UNM.

This conference titled International Conference on Recent Research and issues in Mathematics, Sciences, Technology, Education and Their Applications (ICMSTEA) 2014 is assigned to the 53rd Dies Natalies of UNM. It is primarily organized by Faculty of Mathematics and Natural Science in conjunction with several committee members from other faculties within State University of Makassar.

This conference is conducted in two days from 20th of August to 21st of August in Theater Room, Pinisi Building, State University of Makassar. It involves eleven keynote speakers, ten invited speakers, and approximately 150 parallel speakers.

Ladies and gentlemen, as I previously said, the conference proudly invites twelve keynote speakers coming from several countries. Therefore, on behalf of the committee members, I would like to express my sincere thanks to the keynote speakers, specifically:

1. Professor Max Warxhauwer (Texas State University, USA)
2. Professor Naoki Sato (Osaka Prefecture University, Japan)
3. Professor Peter Hubber (Deakin University, Australia)
4. Professor Susie Groves (Deakin University, Australia)
5. Dr. Frans Van Galen (Utrecht University, the Netherlands)
6. Assistant Professor Duangjai Nacapricha (Mahidol University, Thailand)
7. Dr. Siti Nuramaliati Prijono (the Indonesian Institute of Sciences)
8. Professor Baharuddin Aris (Universiti Teknologi Malaysia)
9. Professor Ismail bin Kailani (Universiti Teknologi Malaysia)
10. Professor Muhammad Arif Tiro (Iowa State University & State University of Makassar)
11. Professor Suratman Woro Suprodjo (Gadjah Mada University, Indonesia)

Next, it is my privilege to thank all organizing committee members who have been showing good work and determination for the accomplishment of this conference. All of them have been working since the beginning of the planning stage and they are still here today for all of us, even though they are very busy with their personal responsibilities.

On this occasion, I would like to apologize to all of you when there are some inconvenience things during the implementation of this conference since we, the organizing committee, as just human being.

Finally, I would like to thank to the speakers and the participants listed in this conference. May I wish you all two fruitful days of interesting and beneficial conference and also that you have a very pleasant stay in Makassar.

Thank you very much for all the attention.

Assalamu'alaykum wa Rahmatullahi wa Barakatuh.

Head of Committee,

Suwardi Annas, Ph.D.

**Forewords from the Dean of Mathematics and Natural Science Faculty,
State University of Makassar**

Bismillahirrahmanirrahim
Assalamu'alaykum Warahmatullah Wabarakatuh

First of all, let us praise to the Almighty, Allah SWT, because of his Blessings and Helps, we are able to gather here to attend International Conference on Recent Research and issues in Mathematics, Sciences, Technology, Education and Their Applications (ICMSTEA) 2014.

The development of education and technology in recent decades grows very rapidly. In addition, they have been specialized into many specific topics. Indeed, for researchers and lecturers, being qualified of a specific field as well as being aware of the contemporary development of other fields are two crucial things. One of the reasons why we undertake the conference is to fulfil those two things. By attending the conference, researchers and lecturers have a good opportunity to share their research findings and to obtain broader descriptions of the development of other general knowledge.

We convey our deep appreciation and gratitude to all of the committees that work from the beginning to support and organize the conference. We also strongly expect the participants of the conference to be continually productive, increase the capacity in conducting a research, and carry out both national and international scientific publications.

Finally, let me again recite thank you to the all participants of the conference who are receptive to spend their time to be present and entirely involved at this events. I wish the conference advantageous for all of us.

Billahi taufiq wal hidayah,

Wassalamu'alaykum Wr. Wb.

Dean of Faculty of Mathematics and Science
State University of Makassar

Prof. Dr. H. Hamzah Upu, M.Ed.

Forewords from Rector of UNM

Bismillahirrahmanirrahim

Assalamu'alaykum Warahmatullah Wabarakatuh

Your respectable, the high officials of State University of Makassar, the committee , the speakers, and the partipants of conference.

It gives me great pleasure to extend to you all a very warm welcome, especially to our keynote speakers who have accepted our invitation to convene the conference.

It is an apportune time to convey to you that UNM is celebrating the 53rd Dies Natalis and it commends the faculty of Mathematics and Natural Science (FMIPA) to be in charge of all activity sequences in the Dies Natalis. However, the support of other faculties is also really influential and gives valuable contribution to the success of the event.

In that celebration, we undertake several agendas including educational and sport activities. The conference, ICMSTEA, is one of our educational activities that covers a wide range of very interesting items relating to mathematics, sciences, education, technology and their applications.

By taking participation of this seminar, it is highly expected to all of us to share our research findings to society and continuously develop new ideas and knowledge. Those things are two significant steps in improving the quality of nations around the world, increasing our familiarity to each other, and even avoiding underdevelopment.

On this good occation, let me quote what Obama said about the education related to this conference and I wish fruitful for all of us:

Every single one of you has something you're good at. Every single one of you has something to offer. And you have a responsibility to yourself to discover what that is. That's the opportunity an education can provide.

Therefore, through this conference, we are able to implement education.

Furthermore, I would like to take this opportunity to express my heartfelt gratitude to all organizing committee especially for Mathematics and Natural Science Faculty that primarily hosts this conference particularly and other Dies Natalis events generally.

Finally, this is a great time for me to declare the official opening of the International Conference on Recent Research and issues in Mathematics, Sciences, Technology, Education and Their Applications (ICMSTEA) 2014.

I wish you a very enjoyable stay in Makassar

I warmly welcome you again, as in Makassar, we say “salamakki battu ri mangkasara”

Assalamu'alaykum warahmatullah wabarakatuh.

Rector of State University of Makassar

Prof. Dr. H. Arismunandar, M.Pd.

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MEASURABILITY OF THE HENSTOCK INTEGRABLE FUNCTION OF VECTOR VALUED FUNCTION ON A LOCALLY COMPACT METRIC SPACE

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Abstract

In this paper, we constructed the measurability of vector valued function on a measurable set in locally compact metric space and then we had proven that a vector valued function which Henstock integrable on a cell in locally compact metric space is a measurable.

Keywords: Measurable function, vector, Henstock integrable function.

1. Introduction

The concept of Lebesgue-measurability of a real valued function is often used in the theory of integral, statistics, and applied mathematics. The Lebesgue-measurability of a real valued function on a cell in $\mathbb{R}$ (the set of all real numbers) have been studied by mathematicians, for instance Lee (1989), Darmawijaya (1992), Indrati (2002), and Manuharawati (2002). By constructing a measurability concept of a function in a vector space, it will be proven that a vector valued function which Henstock integrable on a cell in locally compact metric space is a measurable.

In this paper, a locally compact metric space, especially nondiscrete metric space is denoted by X and vector space, especially Banach space is denoted by Y ,

an extended real numbers by $\mathbb{R}^*$, and $\mathbb{R}^+$ denotes a positive real numbers.

2. Basic Concept

2.1 System of Interval

A nonvoid collection $S \subset 2^X$ is called a **system of intervals** if it satisfies: (Manuharawati, 2002: 11-12):

- (i) for every $p \in X$, $\{p\} \in S$,
- (ii) for every $p \in X$, if $cl(N(p,r))$ compact then $N(p,r) \in S$,
- (iii) if $A \in S$ then A convex, $cl(A)$ compact, $cl(A) \in S$, and $int(A) \in S$,
- (iv) For every $A, B \in S$, $A \cap B \in S$.
- (v) For every $A, B \in S$ there exists a collection of nonoverlapping sets $C_i \in S$, $1 \leq i \leq n$ such that

$$A - B = \bigcup_{i=1}^n C_i.$$

Every an element of S is called an **interval**.

Interval $A \in S$ is said to be **degenerate** if $\text{int}(A) = \emptyset$ and **nondegenerate** if $\text{int}(A) \neq \emptyset$. A

cell is a nondegenerate compact interval. A set $A \subset X$ is called **elementary set** if A is a finite union of intervals. The collection of all elementary sets in X , is denoted by $E(X)$.

2.2 Measure and Measureable Set

A Volume function $\vartheta: E(X) \rightarrow \mathbb{R}$ is called a **measure** on $E(X)$ if:

- (i) $\vartheta(A) = 0$ if $\text{int}(A) = \emptyset$ and $\vartheta(A) > 0$ if $\text{int}(A) \neq \emptyset$
- (ii) $\vartheta(A) \leq \vartheta(B)$ for every $A, B \in E(X)$ with $A \subset B$, and

$\vartheta(\bigcup_{i \in \mathbb{N}} A_i) = \sum_{i \in \mathbb{N}} \vartheta(A_i)$ for every nonoverlapping collection sets $\{A_i\} \subset E(X)$ with

$$\bigcup_{i \in \mathbb{N}} A_i \in E(X).$$

Since X is a locally compact metric space, then for every interval $A \in S$, we have $\vartheta(A) = \vartheta(\text{cl}(A))$ and for every $x \in X$, we have $\vartheta(\{x\}) = 0$. Furthermore, if

$$\mu^* = \inf \left\{ \sum \vartheta(A_i) \right\}$$

for all collection of open interval $\{A_i: A \subset \bigcup A_i\}$, then μ^* is an **outer measure** on X . (Manuharawati, 2002: 20-21).

A set $E \in X$ is said to be **μ^* -measurable** if for every $A \in X$ we have

$$\mu^*(A) = \mu^*(A \cap E) + \mu^*(A \cap E^c).$$

For every interval in X is μ^* -measurable set, and a collection of all μ^* -measurable sets in X is an algebra- σ on X . Furthermore, if

$$\{E_i: i = 1, 2, \dots, n\}$$

is a collection of finite disjoint μ^* -measurable sets, then for $A \subset X$, $\mu^*[\bigcup_{i=1}^n (A \cap E_i)] = \sum_{i=1}^n \mu^*(A \cap E_i)$. (Manuharawati, 2002:22-23).

2.3 Vitali Cover

Let $E \subset X$. A collection $\mathcal{V}$ of cells $A \in S$, with $\vartheta(A) \neq 0$ is said to be a **vitali cover** of E if for every real number $\varepsilon > 0$ and for every $x \in E$, there is an interval $A \in \mathcal{V}$ such that $\vartheta(A) < \varepsilon$.

The following theorem express a property of vitali cover of a set.

Theorem 2.3.1: (Vitali Covering Theorem) *Given a set $E \subset X$ with $\mu^*(E) < \infty$. If $\mathcal{V}$ is vitali cover of E , then for any real number $\varepsilon > 0$ there exists a finite collection of nonoverlapping cells*

$$\{A_i: i = 1, 2, \dots, n\} \subset \mathcal{V}$$

such that

$$\mu^* \left(E - \bigcup_{i=1}^n A_i \right) < \varepsilon$$

(Manuharawati, 2002: 197-198)

2.4 Banach Space

A real function $\|\cdot\|$ on a vector space Y (over field K) is called a norm on Y if for every $x, y \in Y$ and $\alpha \in K$ satisfies:

- (i) $\|x\| \geq 0$,
- (ii) $\|x\| = 0 \Rightarrow x = \mathbf{0}$,
- (iii) $\|\alpha x\| = |\alpha| \|x\|$,
- (iv) $\|x + y\| \leq \|x\| + \|y\|$.

Every $x \in Y$ is called a vector. A vector space Y together with a norm is called a norm space. A Banach space is a complete norm space. (Heuser, 1982:35)

2.5 Henstock Integrable Function

If E is a cell in X and $\delta: E \rightarrow \mathbb{R}^+$, then a finite collection of cell-point pairs

$$P = \{(A_{x_i}, x_i), 1 \leq i \leq n\}$$

$$= \{(A_x, x)\}$$

is called a **Perron δ -fine partition** on E if $x_i \in A_{x_i} \subset N(x_i, \delta(x_i))$ and $\{A_{x_i}\}$ is a partition on E .

If $E \subset X$ is a cell and $\delta: E \rightarrow \mathbb{R}^+$, then there exists a Perron δ -fine partition on E (Manuharawati, 2002: 18).

A function $g: X \rightarrow Y$ is said to be

Henstock ϑ -integrable on a cell $E \subset X$ if there exists a vector $a \in Y$ such that for every real number $\varepsilon > 0$ there exists a function $\delta: E \rightarrow \mathbb{R}^+$ such that for every Perron δ -fine partition

$$P = \{(A_{x_i}, x_i), 1 \leq i \leq n\}$$

$$= \{(A_x, x)\}$$

on E we have

$$\left\| \sum_{i=1}^n g(x_i) \vartheta(A_{x_i}) - a \right\|$$

$$= \left\| \sum_{i=1}^n g(x_i) \vartheta(A_{x_i}) - a \right\|$$

$$< \varepsilon$$

If $A \in \mathcal{S}$ with $\vartheta(A) = 0$, then integral- ϑ Henstock of a function $g: X \rightarrow Y$ on A is defined by null vector (θ) . The set of all ϑ -Henstock integrable function on a cell E is denoted by $H(E, \vartheta)$ and a vector a is called ϑ -Henstock integral value of a function f on E and denoted by

$$(H - \vartheta) \int f = a.$$

(Manuharawati and Yunianti, 2013: 20-21).

Some properties of the ϑ -Henstock integrable function which will be used in discussion are as follow.

Theorem 2.5.1: If $g \in H(E, \vartheta)$, Then for every a cell $F \subset E$, $g \in H(F, \vartheta)$.

(Manuharawati and Yunianti, 2013: 24)

Theorem 2.5.2: A function $g: X \rightarrow Y$ is Henstock ϑ -integrable on a cell $E \subset X$ if and only if there exists an additive function $G: I(E) \rightarrow Y$ with property for any real number $\varepsilon > 0$ there exists a function $\delta: E \rightarrow \mathbb{R}^+$ such that for any Perron δ -fine partition

$P = \{(A_{x_i}, x_i), 1 \leq i \leq n\} = \{(A_x, x)\}$ on E ,

$$\left\| \sum_{i=1}^n g(x_i) \vartheta(A_{x_i}) - G(E) \right\| = \left\| \sum_{i=1}^n g(x_i) \vartheta(A_{x_i}) - G(E) \right\|$$

$< \varepsilon$.

(Manuharawati, 2013: 22-26)

If E is a cell and $I(E)$ is a collection of all subinterval in E , then an additive function $G: I(E) \rightarrow Y$ is called ϑ -Henstock primitive of f on E if $G(\emptyset) = \theta$ (null vector) and for every $A \in I(E)$, $A \neq \emptyset$, we have

$$G(A) = (H - \vartheta) \int_{Cl(A)} g.$$

Theorem 2.5.3: Henstock's Lemma (Manuharawati, 2013: 22-26): If $g: X \rightarrow Y$ ϑ -Henstock integrable on a cell $E \subset X$ with primitive G , then for any real number $\varepsilon > 0$ there exists a function $\delta: E \rightarrow \mathbb{R}^+$ such that for any Perron δ -fine partition $P = \{(A_x, x)\}$ we have

$\| \sum [g(x) \vartheta(A_x) - G(A_x)] \| < 2\varepsilon$.

By this theorem, it is trivial to prove the following theorem.

Theorem 2.5.4: A function $g: X \rightarrow Y$ is ϑ -Henstock integrable on a cell $E \subset X$ if and only if there is an additive function $G: I(E) \rightarrow Y$ with property: for any real number $\varepsilon > 0$ there exists a function $\delta: E \rightarrow \mathbb{R}^+$ such that for any Perron δ -fine partition $P = \{(A_x, x)\}$ we have

$$\| \sum [g(x) \vartheta(A_x) - G(A_x)] \| < \varepsilon.$$

3. Result and Discussion

Again, in this section X denote a nondiscrete locally compact metric space and Y is a Banach space.

3.1 Simple Function

Definition 3.1.1: Let $E \subset X$, θ be a null vector of Y and e be an unit vector (unit element) of Y . A function $\chi_E: X \rightarrow Y$ is said to be a **characteristic function** on E if

$$\chi_E = \begin{cases} e & \text{if } x \in E \\ \theta & \text{if } x \notin E \end{cases}$$

Definition 3.1.2: A function $s: X \rightarrow Y$ is said to be a **simple function** if there are a

finite family of disjoint μ^* -measurable sets $\{X_1, X_2, X_3, \dots, X_n\}$ and finite real numbers $c_1, c_2, c_3, \dots, c_n$ such that

$$X = \bigcup_{i=1}^n X_i$$

and

$$s(x) = \sum_{i=1}^n c_i \chi_{X_i}(x).$$

If c_i is distinct, then this representation is called canonical representation of s .

3.2 Measurable Function

Definition 3.2.1: Let $E \subset X$ be a μ^* -measurable. A function $g: X \rightarrow Y$ is said to be μ^* -measurable on E if there is a sequence of simple function (s_n) on X such that (s_n) converge to g almost everywhere on E .

Theorem 3.2.1: If a function $g: X \rightarrow Y$ is Henstock ϑ -integrable on a cell $E \subset X$, then g is μ^* -measurable on E .

Proof: Let G be a ϑ -primitive of g on E and ε be any arbitrary real number with $\varepsilon > 0$. By Theorem 2.5.4, there exists a function $\delta: E \rightarrow \mathbb{R}^+$ such that for any

Perron δ -fine partition $P = \{(A_x, x)\}$ we have

$$P \sum \|g(x) \vartheta(A_x) - G(A_x)\| < \varepsilon \quad (1)$$

For every natural number n , we choose a partition

$$P_n = \{A_{n_i} : i = 1, 2, 3, \dots, l_n\}$$

on E , with $\text{diam}(A_{n_i}) < \frac{1}{n}$. Since g is ϑ -Henstock integrable on E , then by Theorem 3.5.1, g is ϑ -Henstock integrable on A_{n_i} . Furthermore, we construct a function $s_n: X \rightarrow Y$ such as:

$$s_n(x) = \begin{cases} \frac{G(A_{n_i})}{\vartheta(A_{n_i})} & \text{if } x \in \text{int}(A_{n_i}) \\ \theta & \text{if } x \notin \text{int}(A_{n_i}) \end{cases} \quad (2)$$

Clearly for every natural number n , s_n is a simple function on X .

Let

$$A = \{x \in E : (s_n(x)) \text{ is not convergent to } g(x)\}$$

and

$$T = A - \bigcup_{n \in \mathbb{N}} \left[\bigcup_{i=1}^{l_n} \vartheta(A_{n_i}) \right] \quad (3)$$

Since $\mu^*(\vartheta(A_{n_i})) = 0$, we prove enough that $\mu^*(T) = 0$. From (3), for every $x \in T$ there is a real number $\gamma(x) > 0$ and a natural number m such that

$$\|s_m(x) - g(x)\| \geq \gamma(x).$$

If for every natural number k , we define

$$T_k = \left\{ x \in Y : \gamma(x) \geq \frac{1}{k} \right\},$$

then we have

$$T = \bigcup_{k \in \mathbb{N}} T_k.$$

Furthermore, define a collection $\mathcal{V}$, such as

$$\mathcal{V} = \{A_{n_i} : x \in \text{int}(A_{n_i}) \subset N(x, \delta(x)), i = 1, 2, \dots, l_n; n = 1, 2, \dots; x \in T_k\}.$$

Then $\mathcal{V}$ is a vitali cover of T_k . By the vitali cover theorem, there is a finite collection of cells

$$\{B_{x_j} : j = 1, 2, \dots, l\} \subset \mathcal{V}$$

such that

$$\mu^* \left(T_k - \bigcup_{j=1}^l B_{x_j} \right) < \varepsilon$$

or

$$\begin{aligned} \mu^*(Y_k) &< \sum_{j=1}^l \vartheta(B_{x_j}) + \varepsilon \\ &< k \left[\sum_{j=1}^l \|G(B_{x_j}) - g(x_j)\vartheta(B_{x_j})\| \right] + \varepsilon \\ &< k\varepsilon + \varepsilon. \end{aligned}$$

So, for every natural number k , we have

$$\mu^*(T_k) = 0.$$

Consequently $\mu^*(T) = 0$. This mean that (s_n) convergent to g almost everywhere on E . ■

Theorem 3.2.2: Given two function $g, h: X \rightarrow Y$. If a function g is Henstock ϑ -integrable on a cell $E \subset X$ and $h = g$ almost everywhere on E , then g is μ^* -measurable on E .

Proof: Let

$$B = \{x \in E : h(x) \neq g(x)\}.$$

Since $h = g$ almost everywhere on E , then $\mu^*(B) = 0$. Let T be a set in (3). If $U = T \cup B$, then

$$\mu^*(U) \leq \mu^*(T) + \mu^*(B) \leq 0.$$

Since $\mu^*(U) \geq 0$, then $\mu^*(U) = 0$. So, g is μ^* -measurable on E . ■

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