

PAPER NAME

**Jenie et al.2018Fast Fourier Transforme
d Twin Table Ladder Modulation on Reco
gnising Non Invasive BI**

WORD COUNT

2651 Words

CHARACTER COUNT

14157 Characters

PAGE COUNT

7 Pages

FILE SIZE

437.1KB

SUBMISSION DATE

Apr 25, 2022 8:13 PM GMT+7

REPORT DATE

Apr 25, 2022 8:14 PM GMT+7

● **3% Overall Similarity**

The combined total of all matches, including overlapping sources, for each database.

- 3% Internet database
- 3% Publications database
- Crossref database
- Crossref Posted Content database

● **Excluded from Similarity Report**

- Submitted Works database
- Bibliographic material
- Small Matches (Less than 40 words)
- Manually excluded sources

PAPER • OPEN ACCESS

Fast Fourier Transformed Twin Table Ladder Modulation on Recognising Non Invasive Blood Glucose Level Measurement Optical Device Spectral Responses

To cite this article: Renan P. Jenie *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **187** 012012

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

Fast Fourier Transformed Twin Table Ladder Modulation on Recognising Non Invasive Blood Glucose Level Measurement Optical Device Spectral Responses

Renan P. Jenie^{123*}, Evy Damayanthi^{1*}, Irzaman^{2*}, Rimbawan^{1*}, Dadang Sukandar^{1*}, and Husin Alatas^{2*}

¹Community Nutrition Department, Bogor Agricultural University, Bogor, 16680, Indonesia

²Physics Department, Bogor Agricultural University, Bogor, 16680, Indonesia

³Child Growth and Development Cohort Study, Ministry of Health, Bogor, 10560, Indonesia

E-mail: qwerty_user1983@yahoo.com

Abstract. A comparative trial conducted between February 2017 and April 2017, at Electronic Material Physics Laboratory, Department of Physics, Bogor Agricultural University, West Java, Indonesia. Blood spectral data from participant older than 17 years were assigned to single measurement group. Blood spectral data previously taken from All participant modulated using Twin Table and Ladder (TTL) methods, and further transformed using Fast Fourier Transform (FFT) Methods, and inferred using Fast Artificial Neural Network. The data contained blood glucose level measurement using both prototype of non invasive blood glucose level measurement optical device (prototype) and veni puncture spectrophotometry (veni). The objective was to measure effect of FFT on accuracy of TTL based optical spectral parser engine for prototype compared to veni for fasting normo glucose participants (participants). Main outcome measure: accuracy as rooted means squared error (RMSE) of either TTL and FFT - TTL inference method, smaller is better. Clarke error grid analysis (ega) and Parker ega, and sensitivity and specificity are calculated from the outcomes, larger is better. No randomization of records. The data was inferred using TTL method, and further transformed using FFT method. Analyser are not blinded for either measurement methods. 120 blood spectrum data from volunteerd included in measurement group. The trial is completed for current prototype version, and shall be reopened for future versions. 110 datums were included in the analysis of the primary outcome. RMSE of FFT-TTL 5.16 mg / dl is smaller than TTL 5.27 mg / dl. No difference between Parkes ega of FFT-TTL and pure TTL.. There is insignificant increase in Clarke ega, 99.5 % group A in FFT-TTL compared to 99.3 % group A in TTL. There significance increase of specificity (0.76) but also decrease of sensitivity (0.65) of FFT-TTL compared to TTL. (0.67 and 9.72). Diagnostic accuracy (0.71) and odd ratio (5.83), and Youden index (0.41) remain not changed. No apparent possible case for adverse effect for either methods. No Significant Performance Difference on Fast Fourier Transformed Twin Table Ladder Modulation on Recognising Non Invasive Blood Glucose Level Measurement Optical Device Spectral Responses.

Keywords: comparative study, Fast Fourier Transform, light modulation, optical device, blood glucose level

1. Introduction

To address the problem that current blood glucose level measurement methods is invasive and painful to the user. We proposed to develop alternative that non invasive and thus not painful to the user [1,2]. Spectrophotometry methods known for its potential for non invasive blood glucose level measurement. Several attempts have been made [3,4], None already giving satisfactory result compared to established blood glucose level measurement methods. We have proposed our methods [5], But We did not yet satisfied with the inference engine performance when using plain Bert Lambert Methods or combining it with Twin Table Ladder (TTL) Methods in our previous study [6], so, we use the well known Fast Fourier Transform (FFT) methods for widening the input variance [7], and feed the data using same inference engine to compare the performance [8].

2. Materials and Methods

This a single centre comparison trial, with participant between 17 years to 65 years, purposive sampling, no randomization, no blinding, gold standard controlled, single group trial conducted at Dramaga, West Java, Indonesia. Participants were assigned purposively to one group, focused to fasting range of blood glucose level. Eligible participants were adults from Bogor Agricultural University, aged 17 yo to 65 yo, which are not smoking, hard drinking, undergoing pregnancy, or had done near intervention hard labour. The study took place at Nutrition Services Clinic, Department of Community Nutrition, Bogor Agricultural University, Dramaga, West Java, Indonesia, from December 2016 to January 2017.

In this study, participants sign the informed consent statement and fill each basic profile data. Each participant undergone measurement using prototype first and veni later. In prototype measurement, the device probe is mounted on the distal phalanx, and the results are stored in the local database. In veni measurement, trained practitioner perform blood sampling according to standard laboratory procedures [9] for blood glucose level measurements.

The primary expected endpoint was rooted means squared error (RMSE) below what mandated in ISO 15197:2016, which is 10 mg / dl [10,11]. For proper measurement of sensitivity and specificity of prototype, based on equation by [12] and sensitivity and specificity data by [10,11], with power of 90 % and drop out margin of 20 %, a sample size of 120 participants was necessary. participants, enumerators, and health practitioner informed about prototype and veni methods before trial. As primary endpoint, we use accuracy, defined by RMSE of prototype output while compared to veni output, and compare the RMSE to ISO 15197:2016 standard. Clarke and Parker ega between prototype and veni are calculated using [13] Sensitivity and specificity between prototype and veni are calculated using Stevenson [14]. We utilize R [15] with RStudio [16] and RKward [17] for statistical analysis.

For either TTL and FFT TTL, we use Fast Artificial Neural Network (FANN) [8] as inference engine, as per our previous research [6]. Our tools built on Raspberry Pi 3B [18], and implementing WiringPi [19] for GPIO control. We procure the LED and photodiode for sensor from Thorlabs [20,21], and use I2C protocol for communication [22]. SQLite [23] and Qt [24] are used to build the software needed.

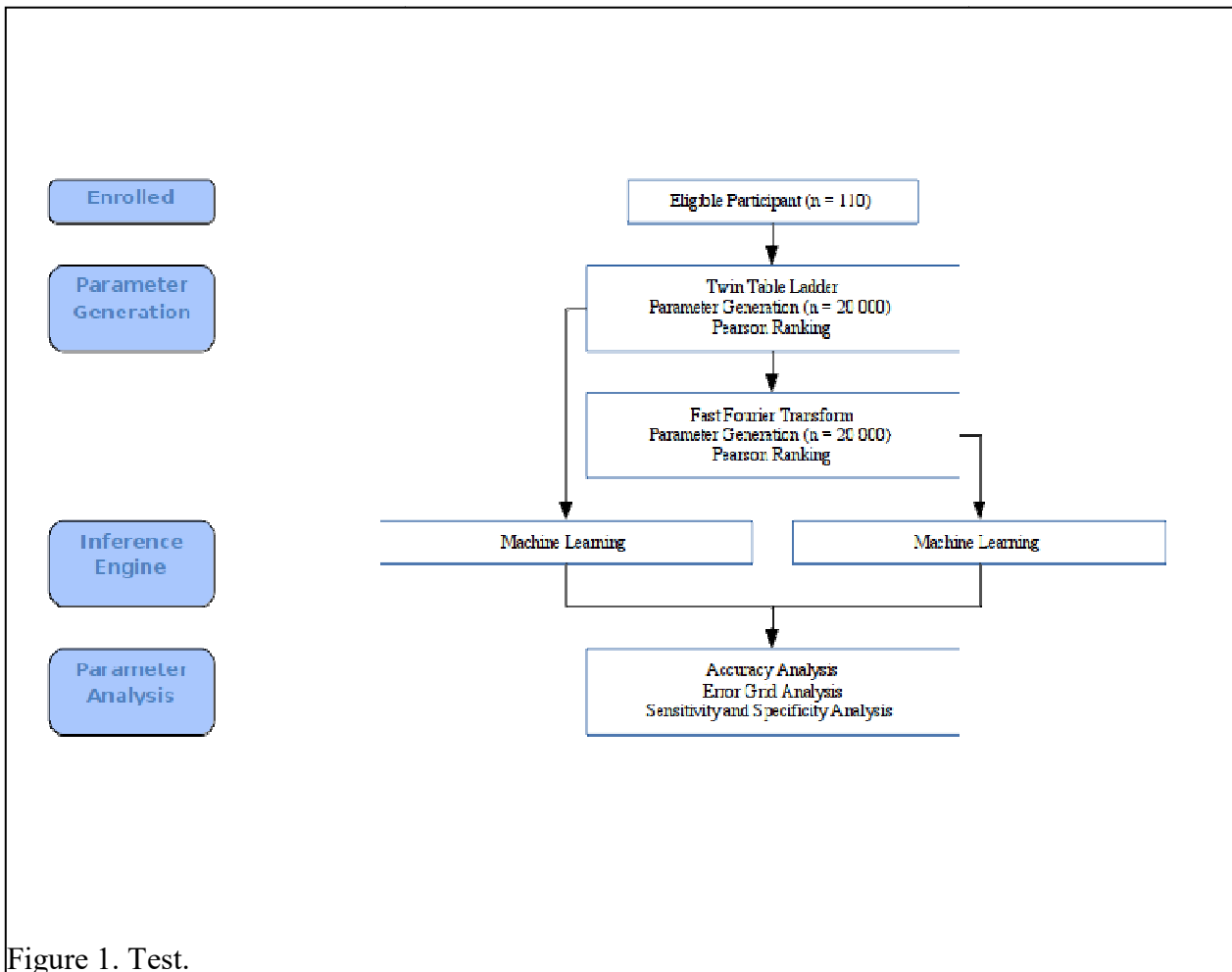


Figure 1. Test.

3. Results and Discussions

Age-eligible participants measured between December 2016 to January 2017. We use 110 participants data out of 120 participants (Figure). The reference measurement range are 60 mg / dl – 10 mg / dl. TTL LED modulation made according to our previous reports [5,25]. FFT equation made using FFTW [7]. We generated 20 000 parameters and uses the 5 best correlation parameters using ALGLIB [26].

Table 1. Competitive matrix.

Parameter	Twin Table Method	Fast Fourier Transform	Reference
Rooted Means Squared Error	5.2672 mg / dl	5.1607 mg / dl	10 mg / dl [27,28]
Clarke Error Grid Analysis (A - E)	99.3 % 0.0 % 0.0 % 0.7 %	99.5 % 0.2 % 0.0 % 0.4 %	100.0 % 0 % 0 % 0 %

Parameter	Twin Table Method	Fast Fourier Transform	Reference
	0.0 %	0.0 %	0 %
Parker Error Grid Analysis (A - E)	100.0 %	100.0 %	100.0 %
	0.0 %	0.0 %	0.0 %
	0.0 %	0.0 %	0.0 %
	0.0 %	0.0 %	0.0 %
	0.0 %	0.0 %	0.0 %
Apparent Prevalence	0.51 (0.46, 0.55)	0.43 (0.40, 0.48)	
True Prevalence	0.47 (0.43, 0.52)	0.47 (0.43, 0.52)	
Sensitivity	0.72 (0.66, 0.78)	0.65 (0.59, 0.71)	
Specificity	0.67 (0.62, 0.73)	0.76 (0.70, 0.80)	
Diagnostic Accuracy	0.70 (0.66, 0.74)	0.71 (0.67, 0.75)	
Diagnostic Odd Ratio	5.53 (3.83, 7.98)	5.83 (4.02, 8.44)	
Number Needed to Diagnose	2.49 (1.96, 3.49)	2.44 (1.94, 3.40)	
Youden's Index	0.40 (0.29, 0.51)	0.41 (0.29, 0.52)	
Positive Predictive Value	0.67 (0.61, 0.72)	0.71 (0.64, 0.76)	
Negative Predictive Value	0.73 (0.68, 0.78)	0.71 (0.65, 0.76)	
Positive Likelihood Ratio	2.25 (1.88, 2.71)	2.67 (2.14, 3.33)	
Negative Likelihood Ratio	0.41 (0.33, 0.50)	0.46 (0.38, 0.55)	

For either TTL and FFT TTL, for inference engine, assisted by FANN [8] we pick the best pick setting. We found out that the best accuracy for TTL achieved using reverse propagation training, Gaussian hidden activation function, and Elliot symmetric activation function, and for FFT-TTL achieved using reverse propagation training, Gaussian hidden activation function, and sigmoid symmetric activation function. Both inference engine built in 6 – 24 – 2 formation. Training and testing result as in (Figure). No severe adverse effect of prototype usage found.

Intervention was implemented for both sexes and all ages, in 50 mg / dl to 100 mg / dl range. No significant difference between accuracy of TTL (5.27 mg / dl) and FFT-TTL result (5.16 mg / dl). Either methods yields accuracy lower than mandated ISO 15197:2016 10 mg / dl [10,11]. That means either methods can be used as inference engine for non invasive glucose measurement. No difference between Parkes Error Grid Analysis (EGA) [13] of FFT-TTL and pure TTL, as both yields 100 % Zone A. There is insignificant increase in Clarke EGA, 99.5 % group A in FFT-TTL compared to 99.3 % group A in TTL. The difference did not powerful enough to determine whether FFT implementation is beneficial. There significance increase of specificity (0.76) but also decrease of sensitivity (0.65) of FFT-TTL compared to TTL. (0.67 and 0.72). Diagnostic accuracy (0.71) and odd ratio (5.83), and Youden index (0.41) remain not changed. No apparent possible case for adverse effect for either methods. FFT-TTL output not giving significant difference to TTL method alone.

4. Acknowledgement

Clinical Trial are registered on Database of Komisi Etik Penelitian Kesehatan, Badan Litbang Kesehatan, Negara Kesatuan Republik Indonesia, no LB.02.01/5.2/KE.493/2016, which also grant the ethical clearance. This works supported by IPTEK 2015 no 079/SP2H/LT/DRPM/II/2016, and

International Research Collaboration and Scientific Publication. Ministry of Research, Technology, and Higher Education, No. 011/SP2H/LT/DRPM/IV/2017., from Negara Kesatuan Republik Indonesia. We would like to thanks Non Invasive Bio-marking Working Group, Bogor Agricultural University, for Their indispensable support for this research.

5. References

- [1] Govada A, Renumadhavi C and Ramesh K B 2014 Non-Invasive Blood Glucose Measurement
- [2] Shinde A A and Prasad R K 2011 Non Invasive Blood Glucose Measurement using NIR technique based on occlusion spectroscopy *Int. J. Eng. Sci. Technol. IJEST*3
- [3] Chowdhury M K, Srivastava A, Sharma N and Sharma S 2014 The Potential Application of Amplitude Modulated Ultrasound with Infrared Technique for Blood Glucose Level Determination in Non Invasive Manner *Biomed. Pharmacol. J.*7 195–206
- [4] Srivastava A, Chowdhury M K, Sharma S and Sharma N 2014 Measurement of Glucose Concentration using Amplitude Modulated Ultrasound with Infrared Technique in Intralipid Phantoms and Human Whole Blood Mixed Intralipid Phantoms of Healthy and Diabetic Subjects *Biosci. Biotechnol. Res. Asia*11 593–602
- [5] Jenie R P, Iskandar J, Kurniawan A, Rustami E, Syafutra H, Nurdin N M, Handoyo T, Prabowo J, Febryarto R, Rahayu M S K, Damayanthi E, Rimbawan, Sukandar D, Suryana Y, Irzaman and Alatas H 2017 Proposed Application of Fast Fourier Transform in Near Infra Red Based Non Invasive Blood Glucose Monitoring System *IOP Conf. Ser. Earth Environ. Sci.*58 012011
- [6] Jenie R P, Irzaman and Nurdin N M 2017 Multi Formulated Regression Slightly Outperform Back Propagation Artificial Neural Network On Recognising Non Invasive Blood Glucose Level Measurement Tools Spectral Responses *Pros. Semin. Nas. Fis.*
- [7] Nikolić M, Jović A, Jakić J, Slavnić V and Balaž A 2014 An Analysis of FFTW and FFTE Performance High-Performance Computing Infrastructure for South East Europe’s Research Communities vol 2, ed M Dulea, A Karaivanova, A Oulas, I Liabotis, D Stojiljkovic and O Prnjat (Cham: Springer International Publishing) pp 163–70
- [8] FANN 2015 Fast Artificial Neural Network Library (FANN)
- [9] Prodia Widyahusada, tbk 2017 Prodia :: Laboratorium Klinik Terbaik – Prodia
- [10] McLaughlin T, Abbasi F, Cheal K, Chu J, Lamendola C and Reaven G 2003 Use of metabolic markers to identify overweight individuals who are insulin resistant *Ann. Intern. Med.*139 802–809
- [11] Bennett C M, Guo M and Dharmage S C 2007 HbA 1c as a screening tool for detection of Type 2 diabetes: a systematic review *Diabet. Med.*24 333–43
- [12] Juneja A and Sharma S 2015 Issues of sample size in sensitivity and specificity analysis with special reference to oncology *J. Cancer Res. Ther.*11 482
- [13] Schmolze D 2015 Package ‘ega’
- [14] Stevenson M, Nunes T, Sanchez J, Thornton R, Reiczigel J, Robison-Cox J and Sebastiani P 2012 epiR: An R package for the analysis of epidemiological data *R Package Version* 09–43
- [15] Dixit Y, Cama R, Sullivan C, Alvarez Jubete L and Ktenioudaki A 2014 Near infrared hyperspectral image analysis using R. Part 5: Animated visualisation of hyperspectral data using R and ImageJ *NIR News*25 15
- [16] Pastoor D 2015 Extending Rstudio’s Functionality to Accelerate Modeler Workflows via Shiny Applications *Journal Of Pharmacokinetics And Pharmacodynamics* vol 42 (SPRINGER/PLENUM PUBLISHERS 233 SPRING ST, NEW YORK, NY 10013 USA) pp S68–S69
- [17] Rödiger S, Friedrichsmeier T, Kapat P, Michalke M and others 2012 RKWard: a comprehensive graphical user interface and integrated development environment for statistical analysis with R *J. Stat. Softw.*49 1–34

- [18] Anwaar W and Shah M A 2015 Energy Efficient Computing: A Comparison of Raspberry PI with Modern Devices Energy4
- [19] Wiring Pi 2017 WiringPi
- [20] Thorlabs, Inc. 2016 Unmounted LEDs
- [21] Thorlabs, Inc. 2016 Unmounted Photodiodes
- [22] Semiconductors P 2000 The I2C-bus specification Philips Semicond.9397 00954
- [23] Oh G, Kim S, Lee S-W and Moon B 2015 Sqlite optimization with phase change memory for mobile applications Proc. VLDB Endow.8 1454–1465
- [24] Akinkuolie B B, Lin C-F and Yuan S-M 2011 A cross-platform mobile learning system using Qt SDK Framework Genetic and Evolutionary Computing (ICGEC), 2011 Fifth International Conference on (IEEE) pp 163–167
- [25] Robiah S, Jenie R P, Dahrul M, Nurdin N M, Iskandar J, Kurniawan A, Rustami E, Syafutra H, Alatas H, Irzaman, Damayanthi E, Rimbawan, Sukandar D, Evriyanti and Budiarti S 2017 Infra Red Light Emitting Diode in 1200 nm Range have Moderate Performance in Detecting Glucose in Human Blood Glucose Model IOP Conf. Ser. Earth Environ. Sci.58 012021
- [26] ALGLIB Project 2017 ALGLIB
- [27] Freckmann G, Schmid C, Baumstark A, Pleus S, Link M and Haug C 2012 System accuracy evaluation of 43 blood glucose monitoring systems for self-monitoring of blood glucose according to DIN EN ISO 15197 J. Diabetes Sci. Technol.6 1060–1075
- [28] Link M, Schmid C, Pleus S, Baumstark A, Rittmeyer D, Haug C and Freckmann G 2015 System Accuracy Evaluation of Four Systems for Self-Monitoring of Blood Glucose Following ISO 15197 Using a Glucose Oxidase and a Hexokinase-Based Comparison Method J. Diabetes Sci. Technol. 1932296815580161.

● 3% Overall Similarity

Top sources found in the following databases:

- 3% Internet database
- 3% Publications database
- Crossref database
- Crossref Posted Content database

TOP SOURCES

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1

hdl.handle.net

Internet

3%

● Excluded from Similarity Report

- Submitted Works database
- Small Matches (Less than 40 words)
- Bibliographic material
- Manually excluded sources

EXCLUDED SOURCES

Renan P. Jenie, Evy Damayanthi, Irzaman, Rimbawan, Dadang Sukandar, Hus... **83%**

Crossref