

CONCEPT NOTE FOR TETFUND 2021 NRF

MINIATURIZATION AND DEVELOPMENT OF ENERGY-EFFICIENT SCHEME FOR
GLOBAL POSITIONING SYSTEM RECEIVERS FOR APPLICATION IN LIVESTOCK
TRACKING SYSTEMS

THEMATIC AREA 19: SCIENCE AND ENGINEERING

I. Background to the Research

The proposed research is on the design, development and miniaturization of Global Positioning System (GPS) receivers (also called trackers) with energy -efficient capabilities to be deployed on cattle (livestock) as a means of producing cattle anti-rustling tracking system. The GPS receivers are to be concealed on the cattle. The overall system provides dynamic cattle tracking and monitoring solutions at any geo-location area using global navigation satellite systems (GNSS) or the GPS. Apart from tracking the cattle's location at any time, this solution would also set up virtual fences around areas restricted to cattle using geofencing application.

This type of research is of importance in most parts of African sub-region especially as some states in Northern Nigeria have been engulfed with different types of livestock theft leading to unprecedented crises. Therefore, the act of herdsmen/farmers losing their cattle/farm produce precipitated the present time banditry and all sort of insecurities (Ajibo et al., 2018).

This technology would be highly needed to combat theft (rustling) and farm encroachment (through geofencing principle) thereby preventing the perpetual loss of lives and properties which definitely will boost the agricultural productivity and safety in the country.

II. Statement of the Problem

The existing GPS receivers (trackers) are too large for livestock monitoring such that when placed around the neck or other part of cattle can be easily seen and removed by rustlers/thieves. Also, the GPS-based system requires enormous energy for location computation and transmission of data through communication (GSM/3G/LTE) transceivers to remote servers. Because of this power requirement, the GPS receivers installed in vehicles are often powered by the vehicles' power system (battery). Therefore in this proposal, the two issues are addressed; the size of the GPS receivers would be reduced to concealable size through miniaturization controlled process while energy-efficient scheme would be developed and implemented to provide sustainable power requirement for the tracking device.

III. Objectives of the Research

The overall objective (aim) is to miniaturize and develop energy-efficient scheme for GPS receivers and deploy them on cattle.

The specific objectives are as follows:

- i. To miniaturize trackers to the size reasonable for concealment on cattle
- ii. To develop and test energy- efficient algorithms for the proposed GPS receivers
- iii. To develop geofencing software for mobile phones.
- iv. To measure radiation emitted from the device and determining its safety limits

- v. To observe if the concealment affects cattle in terms of health and physical wellbeing.

IV. Research Questions

- i. Can current technological advancement in integrated circuits manufacturing produce miniaturize and energy-efficient GPS receivers?
- ii. How diminutive can we scale down GPS receivers' size without losing performance?
- iii. Can concealed trackers affect animal health due to the radiation?

V. Literature Review

Usman et al., (2021) developed and deployed GPS receivers on five cattle with a web-based software for monitoring cattle movement. The solution successfully demonstrated the ability of GPS trackers to monitor cattle movement. However, the GPS receivers measured 4.5/4.5cm, which are too large for stealth concealment. Moreover, the GPS receivers had to be removed and recharged every 24 hours and the principle of geofencing were not also considered in the system development.

Similarly, Qadir and Cooper (2020) developed GPS based tracking systems for cargo ships. The work was application specific, hence cannot be used for cattle anti-rustling tracking scenarios.

Moreover, Atetegba (2018) successfully developed energy-efficient scheme to extend the battery lifespan of ehealth devices employing the power efficiency characteristics of ZigBee's wireless sensor network (WSN). The work demonstrated how predictive sleep mode at the medium access layer (MAC) can extend battery lifespan of the ehealth devices by several months or years. However, the findings were limited to computer simulations and mathematical modelling not applied in asset tracking purposes.

VI. Theoretical Framework

Although smart watches are much smaller than smart phones, yet they are able to replicate all features of a smart phone on the wrist of the wearer. Since smart phones are miniaturized to fit on a wrist, it is empirically possible to scale down the sizes of trackers for concealment by adopting system on a chip (SoC) miniaturization technology using Moore's laws and the contemporary nanotechnology (Michael and Scott, 2010). The SoC could cram GPS, LTE, eSIM, ZigBee, GPU and CPU modules representing the complete GPS receiver system into a single chip under controlled designing and manufacturing process.

Secondly, the proposed energy-efficient scheme leverages ZigBee to create and manage a network of GPS receivers. This network allows GPS receivers to transmit their geolocation coordinates via low-power ZigBee communication. The proposed concept uses sleep- mode (transmission at intervals) and cooperative transmission (one candidate to transmit adjacent

coordinates on behalf of others) principles. The approach presents battery lifespan extension scenario.

VII. Research Methodology

Applied research methodology would be implemented for this research. The following phases are followed to achieve the stated aim (overall objectives) and specific objectives:

- 1) In-depth investigation of existing SoC chips manufacturing process through partnership with international SoC manufacturers like Intel (INTC), Samsung Electronics and so on.
- 2) Design, development and deployment of SoC with embedded GPS, GSM/3G/LTE, eSIM and ZigBee modules
- 3) Development and implementation of energy-efficient (power) management solutions for the proposed GPS receivers
- 4) Design, testing and deployment of geofencing software.
- 5) Determine the health effects of concealed trackers on cattle.

Procedure: The first stage is to design, develop and miniaturize the existing trackers from 4.5/4.5cm to 0.45/0.45 cm (90% reduction). The miniaturization could be done in consultation and possibly collaboration with world best semiconductors manufacturing companies like Intel (INTC), Samsung Electronics etc. After completing the miniaturization process, the trackers are deployed onto the cattle accordingly. 12 cattle would be used in the study; the cattle will be divided into groups of three based on age estimate. Each group will comprise of a bull, a cow with her calf, and a virgin cow. Trackers would be deployed in two groups with the first group miniaturized and concealed while the second not miniaturized (that is maintain the current size). The third group will not have any tracker serving as a control group (those without trackers).

Live tracking and recordings (for playing-back of events) are initiated for at least 1 month and simultaneously taking data and observing their health condition. Some areas around the Federal Polytechnic Bauchi would be selected for virtual geofencing to test its functionality. Application Programme Interface (APIs) for both personal computers and android applications are developed and converted to web based application using PHP, MySQL, JQuery, Bootstrap, and vanilla JavaScript thus providing overall web based management and monitoring solution. This makes the monitoring easy through mobile phones, tablets and personal computers from anywhere, any time.

VIII. Expected Result

The short term result is that concealable GPS receivers will discourage cattle (asset) rustling since rustled cattle can be easily tracked and recovered.

In the long term projection, the solution can be extended to general asset tracking especially in military or police armaments serving as a means of weaponry release control to prevent leakages

from accomplice security personnel as is currently reported from event scenes.. When fully developed at the miniaturized state, this device can be produced in commercial quantity to cover myriad of security solutions to humans trafficking/kidnappings, agricultural and other physical assets .

IX. Innovations: How Different is this from other projects?

The proposed GPS receivers (trackers) will be concealable on the livestock (cattle)with geofencing and efficient energy saving capabilities, which serves as a major milestone over developed available livestock trackers.

X. Estimated Budget

(Estimated Period 2 years)

Item	Description	Amount (₦)
Data Collection, Analyses, Miniaturization, Software development	Semiconductors manufacturers, routine data collection/analyses, power management algorithms, geofencing software for mobile phones etc	12,090,000
Travels		2,350,000
Laboratory consumables	12 cattle (3 bulls, 3 cows with their calves, 3 virgin cows), feeds/drugs, Gen. Set, fuel.	9,000,000
Equipment	GPS/ eSIM/ZigBee/ LTE modules, 3D Printer, Server(s), Wide screens, Oscilloscope, Logic analyzer and Logic probes, RF/EMF testers etc	11,750,000
Personnel Cost	Herders, Veterinarians, Securities ,Technologists, Surveyors	9,400,000
Dissemination of results	Validation workshops with stakeholders, journal publications, etc	1,410,000
Total:		46,000,000

XI. References

1. Ajibo, H. T., Onuoha, Emmanuel C., Obi-Keguna, C. N., Okafor, A.E. (2018). Dynamics of Farmers and Herdsmen Conflict in Nigeria: The Implication to Social Work Policy Intervention, International Journal of Humanities and Social Science, 8(7):157-163
2. Agetegba, M. Y. (2018). A Predictive Media Access Control Protocol for Energy Efficient Wireless Sensor Network for E-health Applications, (Doctoral Dissertation, Sudan University of Science & Technology).
3. Qadir, A. M., & Cooper, P. (2020). GPS-based Mobile Cross-platform Cargo Tracking System with Web-based Application. 8th International Symposium on Digital Forensics and Security (ISDFS) IEEE. pp. 1-7
4. Michael H. and Scott H. (2010). The Future of Integrated Circuits: A Survey of Nanoelectronics, IEEE Xplore, 98(1):11 - 38

5. Usman I.H., Arokhamoni A. I., Yusuf M. A. & Jumba A.M.Y. (2021). Design, Fabrication and Deployment of Anti-Rustling Tracking System, Journal of African Sustainable Development, Sub-Sahara African Academic Research Publication, 21(2):233 -252

XII. Research Team

Name: Engr. Usman Isa Hassan
Rank: Principal Lecturer
Highest Qualification: M.Eng
Area of Specialization: Electronics/Communication

Name: Arthur I. Arokhamoni
Rank: Managing Director, ArtMann Technologies Limited
Highest Qualification: Diploma in Computing
Area of Specialization: Computer Software/Hardware Solutions

Name: Dr. Mohammed A. Yusuf
Rank: Head Business Process Automation, IT Dept. NDIC.
Highest Qualification: Ph.D
Area of Specialization: Wireless Sensor Networks

Name: Engr (Mrs) Fatima Muhammad
Rank: Principal Technologists
Highest Qualification: B.Eng
Area of Specialization: Electrical/Electronic

Name: Dr. Damina Mohammed Sadiq
Rank: Principal Veterinary Research Officer, NVRI,Vom.
Highest Qualification: Master of Veterinary Science (MVSc)
Area of Specialization: Field and Laboratory Diagnosis of Livestock and Poultry Diseases

Name: Surv. Muhammad Shehu Kardam
Rank: Chief Lecturer
Highest Qualification: MSC
Area of Specialization: Geoinformatics

Name: Dr. Abdullahi Mohammed
Rank: Chief Lecturer
Highest Qualification: PhD
Area of Specialization: Animal Production