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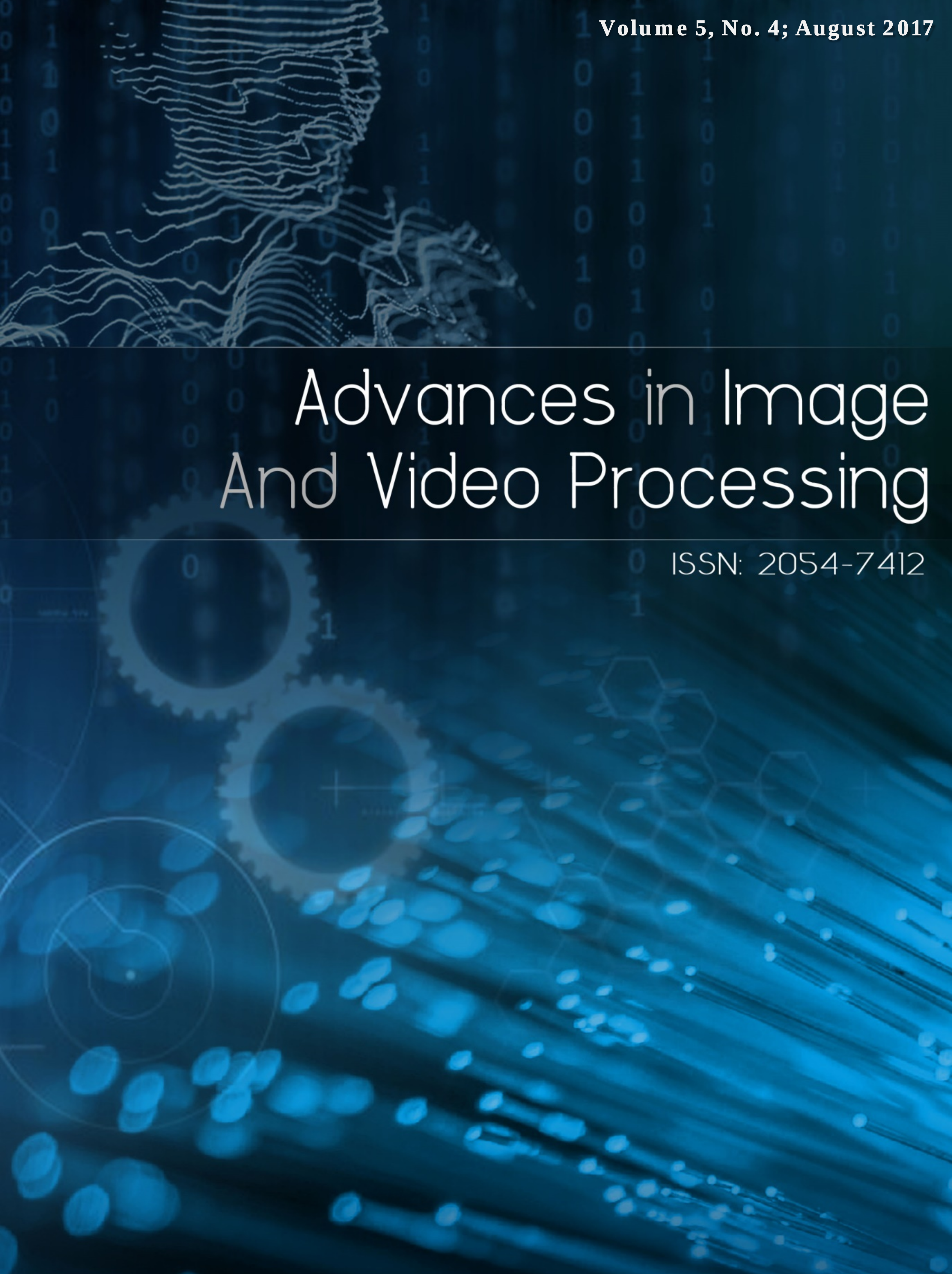

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TABLE OF CONTENTS

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Gait Recognition System Using Gabor Wavelet and Active Gait Differential Image

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ABSTRACT

Gait is a behavioural biometric process that serves to identify persons using their walking style. It is un-obstructive, not easy to conceal and offers distance recognition. Various approaches have been employed to improve the performance and accuracy of gait biometric systems but the performance is yet to measure up to that of other biometric recognition systems. In this work, Gabor wavelets were used to extract Active Gait Differential Image (AGDI) features, while Principal Component Analysis (PCA) was used for feature dimensionality reduction. The classification was performed using Support Vector Machine (SVM) and silhouette images from Chinese Academy of Science Institute of Automation (CASIA) gait dataset was used for testing. The performance was evaluated using accuracy, equal error rate, false acceptance rate and false rejection rate and it gave 99.19%, 1%, 0%, and 2% respectively for the metrics used.

Keywords: Gait, Active Gait Differential Image (AGDI), Support Vector Machine (SVM), Principal Component Analysis.

1 Introduction

Motivated by the need for automated person identification systems in areas that are security-sensitive such as airports, banks, shopping malls and parking lots, identification of humans at a distance has received growing interest in recent times. Video-based human motion analysis is able detect, track and identify people and understudy behaviour of humans from image sequences. Gait is an example of such behavioural biometric that can be noticed and used to identify people from a distance. It is recognizing people through their style of walking, an approach relatively new compared to other biometrics such as fingerprints, iris, palm, and facial [1].

Gait recognition system can be classified to three groups based on the type of sensors used, which are: Floor Sensor Based System [2], Wearable Sensor-based Approach [3] and Video Sensor-based Gait Approach [2]. This work explores the video sensor-based gait analysis approach for our gait recognition system. The framework of a Video sensor-based gait recognition system is shown in Figure 1.

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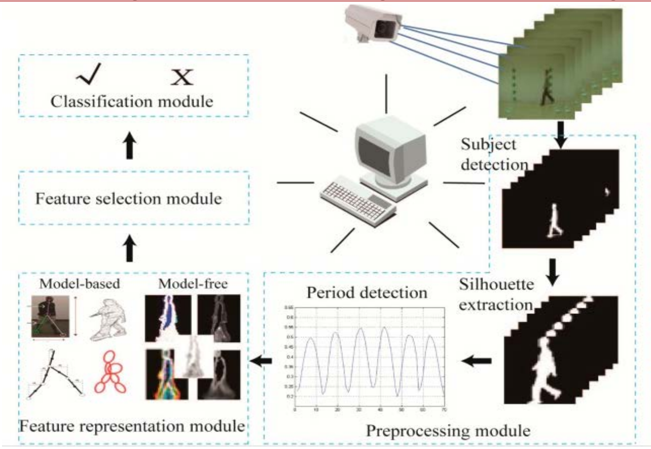

Figure 1: Video-based gait recognition framework [2].

Gait analysis could be model-based or model-free method. In model-based approaches, the structure or motion of the human body is modelled, then features that are matched to the modelled components are extracted. The features contain a combination of information from the shape and dynamics of human gait. Model-free methods also known as silhouette analysis the gait motion directly to identify individuals and does not require a fore knowledge of the gait model. Statistical features from the entire silhouette image without assumption of the underlying structure are extracted. A common method of extracting gait features from silhouette of gait subjects is by measuring body parameters of the subject on a frame by frame basis. Others include, feature image templates, Radon Transform and Canonical Transform. However, some of these feature images fail to preserve the static and dynamic components of walking humans and thus reduces the accuracy of the recognition systems. Therefore, there is the need to construct gait feature image that preserves both static and dynamic components of gait to build human-like recognition system. This work explores the uniqueness of the walking pattern of an individual as a biometric tool using features extracted by Gabor wavelets on Active Gait Differential Image.

The framework of the video sensor based gait recognition system comprises four modules, viz: Pre-processing module which involves detection of subject and extraction of silhouette from the original video, feature representation module, feature selection module and classification module.

2 Literature Review

Previous works in gait recognition adopted several ways of feature extraction, feature representation, feature dimentionality reduction and classification. In building an efficient gait recognition system, some of the key factors to consider include: type of features extracted, method by which the features are extracted, feature dimentionality reduction method, means of classification and consideration of static and dynamic components of gait of the individual subjects. Earlier work in the field of gait employed the use of various devices to determine the gait of a person. The early work of [4] on human motion perception corroborates this point. [4] adopted the use of Moving Light Display (MLD) device. In the experiment, movement of bright spot on the display created and impression of walking, and running to the viewers. This author finally demonstrated that a dynamic array of point light is sufficient to recognize the presence of a 'walker' and went further that the same array is sufficient for the recognition of a particular 'walker'. The work of [5] is an upshot of Johannson work. This authors' experiment is a refinement of the early work of [5] as [5] explored the use of optical device for gait recognition. Gait subjects were tracked by region growing followed by background subtraction. From each silhouette image, spatial (centroid of each silhouette window) and temporal template with U-flow (horizontal component of optical flow field), V-flow (vertical component of flow) and U, V-flow (magnitude of U,V) were extracted. 100% recognition rate of test sequence was achieved in Canonical space after projection. It was however noted by this author that optical flow technique is sensitive to changes in video frame rate and speed of subjects. [6] employed the use of a device called Continuous Wave Rader (CWR) for human gait recognition. Signals reflected from torso, leg and arm of gait subjects were used as gait features when CRW was incident on a person walking towards or away from the radar. A simple binary classifier was developed that classified detection as either a person is present or not present. The classifier result gave a correct classification rate of 80%, leakage rate of 12% and false alarm rate of zero (0%). However, the shortcoming of this method is that it cannot distinguish (discern) whether the subject is moving towards or away from the radar. Further to the method that employed the use of devices to determine gait is another approach known as silhouette based gait recognition approach. This method serves to extract gait features from binary silhouette image of gait subject. Features are extracted by measuring different body parameters of gait subject. [7] extracted four static body parameters directly from the silhouette of gait subjects namely, the body height, torso length, leg length and step length and used them for person identification. It was noted that the method for estimating step length does not explore the periodicity of walking, as a result making it sensitive to tracking and camera calibration errors. In a somewhat similar manner, [8] after tracking the gait subject using background subtraction method with a 2D position of a silhouette, employed stride length and cadence as measured from individual gait subjects as gait features while the Bayesian rule was employed as classifier achieving a recognition rate of 40%. It was observed that the non-inclusion of static body parameters (static components of gait) in the algorithm made the recognition rate to drop compared with [7]. This is an indication that static components of gait enhance the accuracy of gait recognition system. [9] estimated the periodicity in gait sequences obtained from all three (3) views (lateral, oblique and frontal) with respect to the image plane. Gait cycle, differences between bounding box and silhouette (distance vector) were taken as gait features, while eigenspace transformation based on Principal Components Analysis was used for dimensionality reduction. The algorithm gave an encouraging result but covariate factor like changes in clothing was not catered for in the experiment. The algorithm developed by [10] gave 96.3% recognition rate when gait cycle, silhouette height, and width, and gait volume were features extracted from different gait subjects through CCTV cameras that present subject from upper front view, while K-nearest neighbour classifier was employed as the classifier. It was however noted that the system performed better in lateral view of gait subjects.

Gait recognition work has witnessed tremendous improvement over the years which have brought about a drift from the silhouette based method to Feature Image based approach. Recent work in gait serves to mathematically combine silhouette images of gait subjects into a single image template called feature image template. This eliminates the ‘rigor’ of having to extract features on a frame by frame basis from silhouette image of a subject whose gait is to be determined. Examples of feature image include, Gait Energy Image, Frame Differential energy Image, Gait Energy Volume, Active Gait Energy Image and so on. [11] considered feature selection on Gait Energy Image. Supervised and unsupervised feature selection methods were used to extract static and dynamic information of gait subjects while Principal Component Analysis and Median Discriminant Analysis were applied to the selected features for dimensionality reduction. Conclusion was drawn that unsupervised learning feature is advantageous and affords higher recognition rate and lesser computational cost over supervised one. [12] used a new gait representation called Frame Difference Energy Image (FDEI) as against the Gait Energy Image (GEI) employed by [11]. Frieze and wavelet features were extracted from original silhouette image and FDEI representation respectively, while Hidden Markov Model

HMM was used for recognition. This approach could take care of the problem of silhouette incompleteness and occlusion which imparts negatively on recognition. Also, both static and dynamic information of gait subjects were captured in the FDEI representation. The results observed were better than the methods using binary image and Gait Energy Image for recognition.

[13] worked on gait recognition where GEI was constructed and PCA with and without Radon Transform (RT) were applied on the feature image (GEI). RT and PCA were said to have performed the same roles feature extraction and feature dimensionality reduction respectively. An improved recognition system was observed using Carnegie Melon University (CMU) MOBO dataset for gait experiment. The two techniques achieved EER of 94.23%, 82,28% and 90.38% using PCA only and 96.15%, 82.7% and 92.3% for PCA with RT for a slow walk, fast walk, and carrying ball walking conditions respectively.

Feature image template such as Gait Energy Images (GEIs) and its modifications form the basis of many recent appearance based gait recognition systems. [14] proposed an extension of GEI used by [13] to operate in the three-dimensional domain, using binary voxel volumes instead of 2D silhouettes. This proposed Gait Energy Volume (GEV) algorithm showed an improvement over 2D silhouette image in that GEV circumvents the issue of view dependency, as well as having no pose ambiguity, no self-occlusion and allowing easier segmentation of unwanted regions. GEV is computed using

$$GEV\ (K) = \frac{1}{n}\sum_{t=1}^{n} V(t) \tag{1}$$

where n is the number of frames in the K^{th} and V is the aligned voxel volumes.

Features were extracted from the lower part of human MDA was used to extract the effective discriminant features while PCA was employed for dimensionality reduction. Euclidean distance was used for similarity measure between the probe and gallery sequence. This method was evaluated on CMU Mobo database and the in-house captured frontal depth-based gait database. It was however revealed that GEV required a more complex hardware setup, making it impractical for many applications. It is expected that an efficient feature image template with effectual feature extraction and classification procedure would ensure a more accurate gait recognition system. With this background, to build an efficient gait recognition system, there is need to construct a feature image template that contains rich gait information and employ a feature extraction technique that is derived in harmony with the physical world which is suitable for building human-like recognition systems owing to its biological significance. This work explored the biological significance of Gabor wavelets and the strength of Active Gait Differential Energy Image for building a more efficient gait recognition system.

3 Methodology

3.1 Overview of the Developed System

Figure 2 shows the block diagram of the developed gait recognition system, which comprises the pre-processing, feature extraction, feature dimensionality reduction and the classification stages.

The developed gait recognition system was tested with Chinese Academy of Science Institute of Automation (CASIA) gait database. The dataset contains videos of 124 subjects (93 males and 31 females) captured from 11 view angles (ranging from 0^0 to 180^0 with view angle interval of 18^0). It is made up of six normal walking sequences for each subject (normal 01, …, normal 06) conducted from every view angle and there are 3-8 gait cycles of about 40-100 frames for every walking sequence. The video frame size is 320 x 240 pixels, and the frame rate is 25 fps. Figure 3 shows twenty-six (26) images of raw silhouette of one subject from the CASIA gait database, showing various positions of gait while walking. These twenty-six images constitute two gait cycles, which is further divided into two phases namely the stance phase (when the foot is in contact with the ground) and the swing phase (the period when the foot is in the air). From the raw silhouette in Figure 3, images labelled one (1) to thirteen (13) constitute one gait cycle while images labelled fourteen (14) to twenty-six (26) depicts another cycle of gait. It was observed that for each gait cycle, the position of the silhouette (walking individual) at the beginning of the walking process (which denotes the beginning of a cycle) is the same as what is obtainable at the end of the cycle. Active Gait Differential Image was constructed by accumulating the differences between every two frames of the silhouette images as shown in Figure 4. This image contains the Spatial (static) and Temporal (dynamic) components of human gait. The lower and higher intensity regions in the image represent the static and dynamic components of gait respectively.

In the pre-processing stage, effect of distance was removed from the gait images. Every silhouette image was normalized to equal height by employing bicubic interpolation. This helped in ensuring that we have a smoother silhouette image.

The centroid (x, y) of a silhouette is defined as follows

$$x_c = \frac{1}{n}\sum_{i=1}^{n} x_i \ , \quad y_c = \frac{1}{n}\sum_{i=1}^{n} y_i \ , \tag{2}$$

where n is the number of pixels in the silhouette.

Suppose that I_j and I_{j+1} are two adjacent images aligned by the centroid, the gait differential image D_j can be defined as

$$D_j(x, y) = \begin{matrix} 0 \text{ if } \mathrm{I}_j(x, y) = I_{j+1}(x, y) \\ 1 \text{ if } \mathrm{I}_j(x, y) \neq I_{j+1}(x, y) \end{matrix}, \tag{3}$$

where j is the frame number in the image sequence and x and y are the values in the 2D image coordinate.

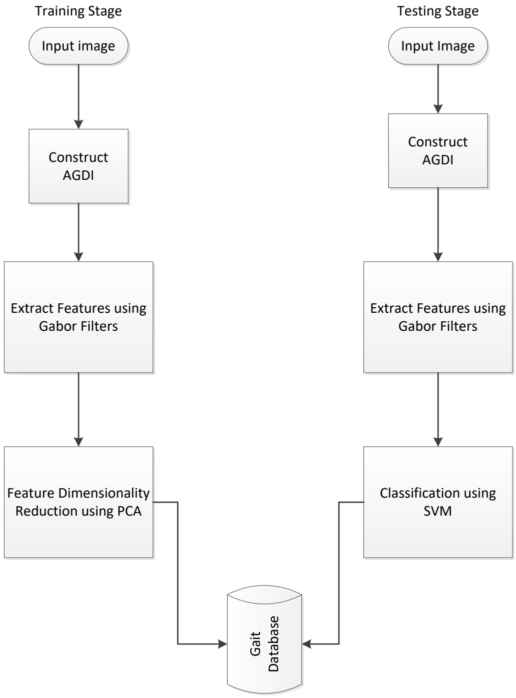

Figure 2: Block diagram of the Developed Gait Recognition System

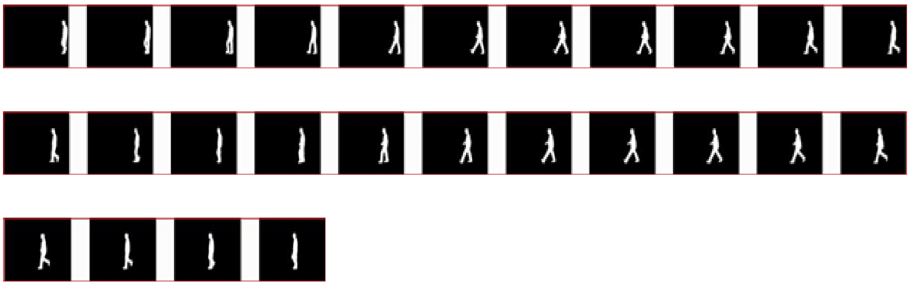

Figure 3. Raw Silhouette Images

Figure 4 Active Gait Differential Image

By overlapping all the differential image of one human gait cycle, the average gait differential image was obtained from:

$$G(x,y)=\frac{1}{N-1}\sum_{j=1}^{N-1}D_j(x,y), \tag{4}$$

where N is the number of frames in the complete gait cycle(s) of a silhouette sequence [16].

In the training and testing stages, Gabor wavelets was performed on the constructed AGDI to extract discriminative features, Principal Component Analysis (PCA) was used for feature dimensionality reduction, while Support Vector Machine (SVM) was employed for classification of the stored features.

Gabor function acts as a low-level oriented edge and texture discriminators, and is sensitive to different frequencies and scale information. Mathematically, a 2D Gabor function, g, is the product of a 2D Gaussian and a complex exponential function. The general expression is given by

$$g_{\theta,\sigma,\lambda}(x,y)=\exp\left[-\frac{1}{2}(x,y)M(x,y)^{T}\right]\exp\left[\frac{j\pi}{\lambda}\cos\theta+\mathrm{y}\sin\theta\right], \quad (5)$$

where θ represents the orientation, λ is the wavelength, and σ represents scale at orthogonal directions.

By selectively changing each of the Gabor function parameters the filter can be tuned to a pattern arising in the images. The Gabor filter responds by convolving a Gabor function with image patterns I (x,y), which helps to evaluate their similarities. Gabor response at point (x_o, y_o) is defined as

$$G_{\theta,\lambda,\sigma}(x_o,y_o)=(I*g_{\theta,\lambda,\sigma})(x_o,y_o)=\int(x,y)\ \mathrm{g}_{\theta,\lambda,\sigma}(x_o-x,y_o-y)dxdy, \quad (6)$$

where $*$ represents convolution.

The Gabor response obtained emphasized basically three types of characteristics in the image. The edge-oriented feature, texture-oriented feature and a combination of both. To emphasize different types of image characteristics the parameters σ, θ, and λ of the Gabor function are varied. The variation of σ changed the scale at which the world is being viewed, and the variation of λ, the selectivity to high/ low frequencies. An adequate combination of σ, θ, and λ were found to represent parts of objects for recognition task.

Large arrays of (high dimension) features were extracted from each subject using Gabor. However, since the dimension was too large and so unsuitable for classification, PCA was employed for feature dimensionality reduction, because it represents data in a low dimensional space while maintaining the Euclidean structures of the data in a high dimensional space. PCA reduced the dimension of features extracted via Gabor by selecting the most discriminative features that best represent the subject. A total of ten (10) discriminative feature data was adopted for each subject. Support Vector Machine (SVM) learning algorithm was used to analyze data and recognize patterns to determine whether the gait of the subject being tested is available in the database or not. If the gait pattern of the tested subject matches the feature in the database the system accepts. If otherwise, the system rejects the tested subject. The algorithm was implemented in MATLAB 8.1.0.64 version and performance evaluation was done using the metrics of Accuracy, False Acceptance Rate, False Rejection Rate and Equal Error Rate.

Performance evaluation metrics used are:

1) Accuracy - the extent of reliability of the biometric system.

$$\text{Accuracy} = (\text{Items classified correctly} \div \text{All classified items}) \times 100 \quad (7)$$

2) False acceptance rate (FAR) –The proportion of impostors that are accepted by the biometric system.

$$FAR(t) = FMR(t) \times (1 - FTA) \quad (8)$$

3) False rejection rate (FRR) –The proportion of authentic users that are incorrectly denied,

$$FRR(t) = FTA + FNMR(t) \times (1 - FTA) \quad (9)$$

Equal error rate - this corresponds to the point at which the FAR and FRR crossed FAR (t) = FMR (t), which is the compromise between FAR and FRR.

4 Results

The performance evaluation results of the system as presented in Table 1, shows accuracy, FAR, FRR and EER of 99.19%, 1%, 0%, and 2% respectively. The result of the performance of the developed method using Active Gait Differential Image (AGDI) and Gabor feature extraction technique over other feature image templates is presented in Table 2. The result in terms of accuracy of the developed AGDI feature extraction with Gabor filter method was compared with earlier methods as shown in Table 2.

Table 1 Performance Evaluation of the Proposed System

Evaluation Metric	Result (%)
Accuracy	99.19
Equal Error Rate	1
False Rejection Rate	2
False Acceptance Rate	0

Table 2: Comparison of new Feature Image Template and Existing Feature Images.

SN	Feature Image Method	Performance (%)
1	Gait Flow Image (GFI) [17]	98
2	Enhanced Gait Energy Image [18]	75
3	Frame Differential Energy Image (FDEI) [2]	94
4	Structural Gait Differential Image (SGDI) [19]	89.29
5	Gait Energy Image (GEI) [16]	60.37
6	Gait Entropy Image (GEnI) [20]	80.1
7.	Developed Active Gait Differential Image (AGDI)	99.19

Gait flow image [17], Enhanced Gait Energy Image [18], Frame Differential Energy Image (FDEI) [2], Structural Gait Differential Image (SGDI) [19], Gait Energy Image (GEI) [19], Gait Entropy Image (GEnI) [20] gave 98%, 75%, 95%, 89.29%, 60.37%, 80.1% respectively as against 99.19% by the developed AGDI with Gabor filter method.

Table 3. Compares the accuracy of the proposed gait recognition system with existing silhouette-based gait recognition methods. Features were extracted on outermost contour of each silhouette image on a database of one hundred (100) people while employing Neural Network and Exepler Neural Network pattern classification techniques. The highest accuracy achieved in the combination of four (4) different techniques was 97.67% as against 99.19% accuracy of the developed system on a database of one hundred and twenty-four (124) people. Improved recognition rate was achieved due to the efficiency of AGDI and a more adequate feature extraction and classification methods employed in the experiment.

Table 3: Comparison of results with existing Silhouette-Based Methods

Method	Classifier	Accuracy (%)	Error rate (%)
PCA [21]	NN	72.33	16
PCA+MDA [21]	NN	96.67	8
PCA [21]	Exempler NN	69	11
PCA+MDA [21]	Exempler NN	97.67	5
PCA+Gabor **(Developed system)**	SVM	99.19	1

5 Conclusion

In this paper, we presented a gait recognition system that uses Gabor wavelet features extracted from Active Gait Differential Images and SVM as the classifier. The developed system gave accuracy, FAR, FRR and EER of 99.19%, 1%, 0%, and 2% respectively, which shows some improvement over earlier methods. Future research in this area can be focused on gait images with various covariate conditions such as different view angles, clothing, carrying conditions (backpack, briefcase, and handbag), type of shoe worn, surface accessories, injury, and mood of the individuals.

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A Structural Analysis on the Creativity, Self-Leadership, Self-Determination, Career Decision-Making Self-Efficacy, and Career Preparation Behavior of College Students who participated in the Training Courses from Lifelong Educators

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ABSTRACT

We conducted a structural analysis on the creativity, self-leadership, self-determination, career decision-making self-efficacy, and career preparation behavior of college students who participated in the training courses of lifelong educators. The results are as follows: First, the creativity has meaningful influence on career preparation behavior. Second, the creativity has meaningful influence on self-leadership, self-determination, and career decision-making self-efficacy. Third, their self-leadership and self-determination, and career decision-making self-efficacy has meaningful influence on career preparation behavior. Fourth, we confirmed that self-leadership, self-determination, and career decision-making self-efficacy have meaningful mediation influence between the creativity, and career preparation behavior.

Keywords: College students, Creativity and Self-leadership, Self-determination, Career decision-making self-efficacy, and Career preparation behavior

1 Introduction

In modern society, college students, who struggle to find their place in society, are required to make great efforts to develop various skills such as creativity, self-leadership, self-determination, career decision-making self-efficacy, and career preparation behavior. In order to help them develop such skills, many countries and universities are recently providing various training programs, as well as operating job centers, supporting work experience, implementing work & study systems, and promoting LINC projects. These support programs need to be continued to lower the high youth unemployment rate and help college students find jobs in societ.

Career preparation behavior leads college students to engage in actual and concrete behavior to achieve their goals, for which it is being considered as a very important factor in career decision-making [1-5]. It is, therefore, very significant for this study to analyze the creativity, self-leadership, self-determination, career decision-making self-efficacy, and career preparation behavior of college students who are preparing to find jobs.

Therefore, it is meaningful to investigate the structural analysis between their creativity, and self-leadership, self-determination, career decision-making self-efficacy, and career preparation behavior. In order to provide theoretical and empirical data to promote career preparation behavior in college students based on the results of the analysis, the following research questions were assigned:

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First, how does college students' creativity influence their career preparation behavior? Second, how does college students' creativity influence their, self-leadership, self-determination, and career decision-making self-efficacy? Third, how does college students' , self-leadership, self-determination, career decision-making self-efficacy influence career preparation behavior? Fourth, how does college students' creativity influence career preparation behavior with mediation of, self-leadership, self-determination, and career decision-making self-efficacy?

1 Research Methods and Procedures

1.1 Research Objects

Table 1. Demographic characteristics (n=392)

variables	contents	frequency (n)	proportion (%)	variables	contents	frequency (n)	proportion (%)
sexuality	man	185	47.2	Participation period	1-2 semesters	40	10.2
	woman	207	52.8		3-4 semesters	76	19.4
years	20-21 years(a)	87	22. 2		5-6 semesters	182	46.4
	22-23 years(b)	179	45.7		7-8 semesters	94	24.0
	24-25 years(c)	96	24.5		9-10 semesters	39	9.95
	25 years over(d)	30	7.7	courses number completed	1-2 courses	62	15.9
academic years	year 1	12	3.1		3-4 courses	64	16.3
	year 2	79	20.2		5-6 courses	79	20.2
	year 3	116	29.6		7-8 courses	64	16.3
	year 4	185	47.2		9-10 courses	41	10.5

1.2 Measurement Instruments

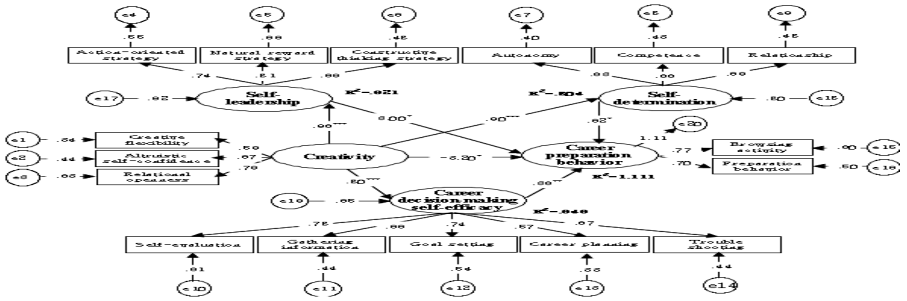
As a measuring tool of creativity, a tool developed by Eun Lee Jeong and Yong han Park[3], which consists of total 36 questionnaires, including 8 on creative flexibility and 5 on and alternative solving and 6 on altruistic self-confidence and 6 on relational openness and 3 on distinctive independence and 3 on exploratory immersive. As a measuring tool of self-leadership the RSLQ(Revised Self-Leadership Questionnaire) was measured with the measurement scale developed by Houghton & Neck[4], which consists of total 35 questionnaires, including 18 on action-oriented strategy and 5 on natural reward strategy and 12 on constructive thinking strategy. As a measuring tool of self-determination, a tool used by Jinsuk Ryu [2] and Myeongshin Park [9-10], which consists of total 15 questionnaires, including 6 on autonomy and 3 on efficacy and 6 on relationship. As a measuring tool of career decision-making self-efficacy, a tool translated by Gihak Lee and Hakju Lee [17] for domestic college students from a scale developed by Betz & Klein & Taylor [6], which consists of total 25 questionnaires, including 5 on each of the following: self-assessment: information collection, setting goals, career plan, and problem solving. As a measuring tool of career preparation behavior, a career preparation behavior measuring tool was used which was revised by Taeyong Ko [7] from a measuring tool developed by Bonghwan Kim [6], which consists of total 17 questionnaires, including 12 on activities of exploration and 5 on activities of preparation.

1.3 Data Collection and Analysis

SPSS 22.0 Program was used for the calculations of Cronbach's reliability coefficient and correlation analysis, descriptive statistics analysis and frequency analysis to analyze collected data. Then, the confirmatory factor analysis was conducted using the AMOS 22.0 Program. To validate the structural equation modeling, the effect on measurement model was identified.

2 Research Results

2.1 Empirical Tests on Structural Relations of the Measurement Model



*p <.05 **p <.01 ***p <.001, Path Coefficient: Regression Coefficients (*B*)

Figure. 2. Structural relations model the path of the measurement model

Table 2. Fit indices for the measurement model

Division	X^2	p	df	CFI	GFI	AGFI	IFI	TLI	RMR	RMSEA
Fit indices	560.309	.000	97	.943	.938	.973	.944	.905	.039	.071
Optimal cutoff	-	< .05	-	> .90					< .05	< .08

2.2 Decomposition of the Influence on the Structural Path of the Measurement Model

Table 3. Path coefficients and explanatory power of the measurement model (SMC/R)

hypothesis path			B	***B***	S.E.	C.R.
creativity	->	career preparation behavior	-3.465	-3.202	1.518	-2.283*
creativity	->	self-leadership	.915	.960	.063	14.527***
creativity	->	self-determination	.679	.896	.059	11.454***
creativity	->	career decision-making self-efficacy	.695	.803	.061	11.413***
self-leadership	->	career preparation behavior	.3.405	3.000	1.519	2.241*

self-determination	->	career preparation behavior	.886	.621	.408	2.172*
career decision-making self-efficacy	->	career preparation behavior	.455	.364	.160	2.835**
self-leadership SMC/R^2 .921(92.1%), self-determination SMC/R2 .804(80.4%) career decision-making self-efficacy SMC/R^2 .646(64.6%), career preparation behavior SMC/R^2 1.111(111.1%)						

*p <.05 **p <.01 ***p <.001

2.3 Decomposition effect on the Structural Model of the Measurement Path

Table 4. Degradation effect of the measurement model

variables		life core ability			
		direct effects	indirect effects	total effects	path effects
exogenously variables	creativity	.960	-	.960	creativity -> self-leadership
		.896	-	.896	creativity -> self-determination
		.803	-	.803	creativity -> career decision-making self-efficacy
		-3.202	3.728	.526	creativity -> career preparation behavior
endogenous variables	self-leadership	3.000	-	3.000	self-leadership -> career preparation behavior
	self-determination	.621	-	.621	self-determination -> career preparation behavior
	career decision-making self-efficacy	.364	-	.364	career decision-making self-efficacy -> career preparation behavior

2.4 Mediating Effects between the Measured Variables for the Measurement Model Validation

Table 5. Mediating Effects validation result between the measured variables for measurement model

variables path between			Z_{ab}
independent variable	medium variable	dependent variable	
creativity	self-leadership self-determination career decision-making self-efficacy	career preparation behavior	1.959* 1.514* 2.242*

*p <.05

3 Discussion and Conclusion

Research results are as follows: First, creativity has a positive significant influence on career preparation behavior. Second, creativity has a positive significant influence on self-leadership, self-determination, and career decision-making self-efficacy. Third, self-leadership, self-determination, and career decision-making self-efficacy have a positive significant influence on career preparation behavior. Fourth, creativity has a significant influence on career preparation behavior with a mediation of self-leadership, self-determination, and career decision-making self-efficacy, which means creativity has an indirect influence on career preparation behavior through self-leadership, self-determination, and career decision-making self-efficacy. College education can influence career preparation behavior of college students through the creativity, self-leadership, self-determination, and career decision-making self-efficacy.

Based on the findings of this study, we have a list of suggestions for these types of programs: First, to promote activities related with the future career of college students, college students should be supported for an immersion in with conviction of their goals and in planning for the right career direction Second, developing and managing a systematic program to improve the career preparation behavior of college students should be implemented, through which their autonomy, efficacy, and relationship can be improved for career preparation behavior to be able to be applied to various fields of life and real employment. Third, applying a variety of teaching methods is necessary in order to establish an appropriate community in time for career guidance and school activities as career preparation behavior improvement is influenced by creativity, self-leadership, self-determination, and career decision-making self-efficacy.

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Spatial Analysis of Gully Erosion Control Measures in Gombe Town, Gombe State Nigeria

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ABSTRACT

The performance of gully erosion control measures in Gombe metropolis is presented. This paper aimed at assesses the spatial distribution of gully erosion control measures in Gombe town since 2004 to 2015. The objectives of the research are to identify the spatial distribution of gullies in Gombe town and to analyze the length of gullies so far checked or controlled. High resolution images of the study area (Quick bird 2004 and 2015) were acquired for GIS analysis and ground truth measurement. Information gathered from field and image digitization was used to determine increase in the size and length of gully erosion from 2004 to 2015. In order to identify recently developed gullies, ArcGIS software was used to perform spatial analysis. Result of the study revealed that most of the previous uncontrolled or partially checked gullies have increased in length to 131.02 km as against the 121.50 km in 2003. This represents an increase of 9.72 km (7.42 %) over the 13 years period or about 75 metres annual increase in gully length. The analysis further revealed that there were 615 first order gullies representing 62% second order has 173 gullies or 18%, third order gullies has 89 in number and represent 12%, the fourth order has a total of 51gullies in number representing 5%, the fifth order consist of 30 gullies or 2% and the sixth order number which is the main gully has 11 in number representing 1.0% respectively. Out of the 131.02 km length of gully erosion inventory in Gombe town in 2015 only 41.32 km length has been controlled and 35.92 km under engineering method representing 87%; 5.1 km (12.3%) length of vegetation and only 0.3km under stone wall control measures out of the total 41.32 km length of the three methods of control measures under study. It is therefore suggested that apart from government efforts other stakeholders should be encourage and participate in gully erosion control especially adoption of vegetation method which is affordable, accessible and acceptable.

Keywords: Gullies, Control, Spatial, Vegetation, Gombe

2 Introduction

The formation of gullies has become one of the greatest environmental disasters facing residents of Gombe towns (Lazarus, et al. 2012). This town is fast becoming hazardous for human habitation. Hundreds of people are directly affected every year and have to be re-located. Large areas of agricultural lands are becoming unsuitable for cultivation as erosion destroys farmlands and lowers agricultural productivity. The demographic increase and various infrastructural development meant to improve the standard of living of the people has on the other hand devastated the environment especially where uncoordinated development is taking place. Each yearly rainy season is accompanied by increases in gully length, depth and width. The incidents of gully have caused much concern to successive governments of Gombe state and other stakeholders where concerted efforts of control

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measures were taken each year. Various methods adopted by government and residents of Gombe town in gully erosion control measures include engineering, tree planting or vegetation, stone wall sand bag and diversion of runoff. However, the control measures has not kept pace with rate of gully expansion or growth, as some of these measures have been fully or partially successful while others have failed, partly due to inadequate fund to adopt holistic method of control measure that stand the test of time.

This paper aimed at assesses the spatial distribution of gully erosion control measures in Gombe town since 2003 to 2016. The objectives of the research are to identify the spatial distribution of gullies in Gombe town; to analyze the length of gullies so far checked or controlled; and to assess the lengths of gullies unchecked in the study area. It is hoped that the results presented herein would be of interest to planners and designers of gully control measures in Nigeria and elsewhere where similar gully problems occur.

4 Methodology

4.1 The study Area

Gombe metropolis is located between latitude $10^{0}\,0^{1}$N to $10^{0}\,26^{1}$N and longitude $11^{0}\,01^{1}$E and $11^{0}19^{1}$E. It shares a common boundary with Akko L.G.A on the south Yalmaltu-Deba to the East and Kwami to the North. It occupies a total land area of about 56km^2. Based on koppen's (1929) classification, Gombe is within the savannah climate (AW) type of climate. It is a reasonably wet and dry area, having a mean annual rainfall and temperature of 850mm and 28^{0} C respectively.

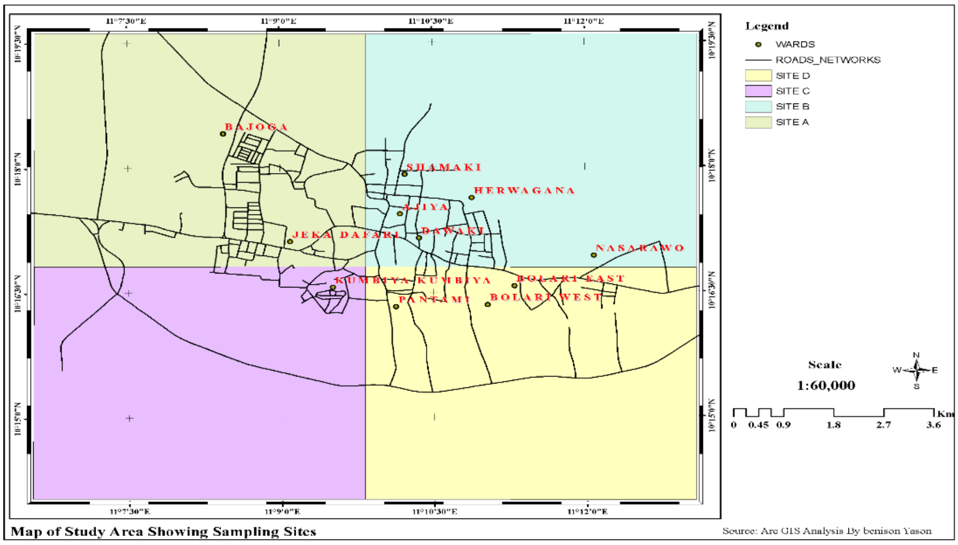

Figure 1: Study area, Gombe Metropolis. Source: GIS analysis/Field work, 2016.

However annual rainfall is concentrated between the month of June to September with its maximum in July and August. There is little information on the rainfall intensity. However, a heavy rainfall especially in July and August is associated with storms of high intensity accelerating gully erosion (Balzerek, *et al.,* 2003).

Gombe town is underlain by the Gombe Sand stone and Pindiga formation. There are estauritic gift Sandstone; Silt stone, shale and Iron stone. There are also quite trace of marine shale's and mud stone that belong to the Pindiga shale and Yolde formation respectively that belong to the Paleocene and Cenozoic ages. Gombe town is generally a low lying region except for the high land areas such as the Gombe hill and the Liji hills (Arabi *et al.,* 2009).

The soil of Gombe is that of tropical ferruginous type. They are dark grey in color and have PH value ranging from 4 to 6 depending on the location. The soil are intensively formed as a result of incomplete weathering of the basement rock traditionally and management practices have however made them susceptible to erosion and reduced, then water holding capacity.

The vegetation of Gombe area can be described as Sudan savannah with open grassland and shrubs which dries up during the dry season. The natural vegetation has been greatly affected and modified over most of the areas by human activities such as overgrazing, bush burning, construction and agriculture. The predominant tree species consist of *Afzillia Africana, parkai bigiobosa, Adamsonia digitata and tamarindus indica*, instead of continuous grass cover, the vegetation has been cleared in places for farm and building.

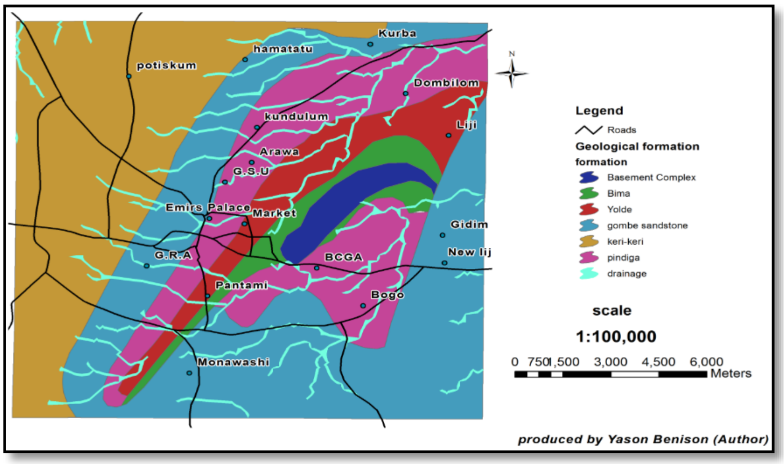

Figure 2: Geological map of Gombe metropolis

The pattern of population growth of Gombe town was slow from 1900 to 1952 (300 to 18,500 people) while; from 1964 to 1991 the population growth has increased tremendously from 47,000 to 138,000. However, from the year 1996, when Gombe became the state capital, there was a noticeable sharp increase in population from 169, 894 (1996) to 219,946 in 2006 (Tiffen, 2006) and 312,467 in 2010 (National Population Commission, 2007).

4.2 Materials and Methods

A methodological frame work in the context of GIS, remote sensing and related techniques was employed, using both spatial and non-spatial datasets to the study of gully erosion phenomenon in the study area. Datasets for this study include both spatial and the non spatial data, some of which can be categories into primary and secondary data. The primary data are information that consists of information gathered from the field investigation, measurement and observation. High resolution images of the study area (Quick bird 2004 and 2015) were acquired for GIS analysis, this included vector and raster formats generated from on-screen digitization and classification while the secondary are existing materials to be collected from literature reviews and others materials.

Information gathered from field and image digitization was used to determine increase in the size and length of gully erosion from 2004 to 2015. In other to identify recently developed gullies, ArcGIS software was used to perform spatial analysis; while Excel spread sheet provide the platform for database development for subsequent transfer onto ArcGIS platform in a loose coupling approach.

The collected images are pre-processed by radiometric or geometric corrections. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor. Image enhancement is solely to improve the appearance of the imagery to assist in visual interpretation and analysis. The image pre-processing, enhancement and transformation operations are done using ERDAS IMAGINE 9.1. To segregate the study area from the images, geo-referencing of the satellite images have been performed. They are transformed to the Universal Transverse Mercator (UTM) map projection system.

5 Findings and Discussion

5.1 Spatial Distribution of Gully Length in Gombe Town

Previous studies conducted in Gombe township erosion control and the ministry of environment (2003) on the yearly physical assessment of gully situation after each rainy season shows that the total length of gully within the metropolis is about 121.5km, out of this only 5.6km in length have been controlled while 7.62km have been partially controlled leaving about 107.3km still uncontrolled, (SEEDS 2006). Comparing the result of the manually digitized gully and ground truth measurements in 2016 shows that most of the previous uncontrolled or partially checked gullies have increased in length to 131.02 km as against the 121.50 km in 2003. This represent an increase of 9.72 km (7.42 %) over the 13 years period or about 75 metres annual increase in gully length, despite various control measures taken by previous and current government (Table I and Fig. 3).

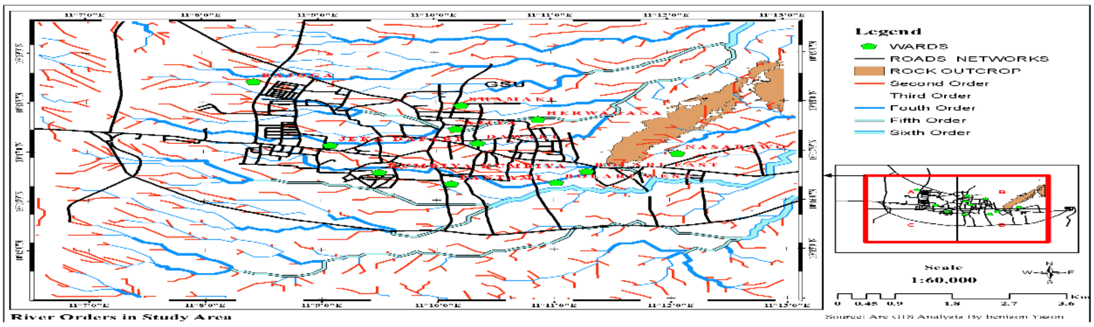

Figure 3: Spatial distribution of gully Erosion in Gombe metropolis. Source: GIS analysis 2016

Table I: Spatial Distribution of Gully Erosion Length in Gombe Town (2003 and 2016)

S/No	Name of Gully Sites	Length in Km	
		2003	2016
1	FCE (T) – Arawa	10.6	12.34
2	Mallam Inna – Gombe Hill	4.9	4.6
3	Mallam Inna – Arawa	2.20	2.85
4	Arabic T. C- Mallam Inna	3.20	3.54
5	Railway – Mallam Inna	0.5	1.0
6	GSU - Railway	1.50	1.50
7	FCE (T) staff school – Arabic TC	3.8	4.3
8	Musaba clinic – Tudun wada	1.9	1.9
9	Ministry of Agric –Tudun wada	1.1	1.1
10	Federal lowcost – Dukku motor park	1.8	0.8
11	Liman Pri Sch – Mallam Inna	2.8	0.8
12	Sabon Fegge – Railway	2.5	3.2
13	Govt comp sc Sch – former GSEMA	2.91	3.4
14	Railway – Gandu day SC School	2.92	1.5
15	Railway - Police barrack	3.56	1.5
16	Herwagana – Gombe hill	4.35	3.1
17	Bubayero – Herwagana	1.0	1.0
18	Dawaki – Herwagana	0.7	0.7

19	Gombe Line park – Central pr Sch	0.85	0.85
20	Old grave yard – Bubayero pr sch	3.3	2.3
21	Federal Lowcost – old grave yard	1.65	2.0
22	State secretariat – old grave yard	2.43	2.43
23	Federal lowcost – Bubayero pr Sch	1.2	1.0
24	Jallo waziri pr sch – Kcc Computer	0.55	0.55
25	Govt SC Sec sch – Fed lowcost	1.35	0.35
26	Railway – AYU Quary	1.74	1.2
27	Bogo – Doma	5.6	4.6
28	J/Fari – Yelenguruza	6.15	4.3
29	Shongo estate – Civil service com	4.7	4.4
30	Ashaka road – Civil service com	2.67	2.29
31	Ahmad Gombe pr sch – J/Fari	1.36	1.36
32	Ministry of works – J/Fari	0.55	0.55
33	Liberty – J/Fari	0.45	0.45
34	Gombe Int Pr Sch – J/ Fari	2.23	2.23
35	Miyetti cinema – Gombe Int sch	0.5	0.5
36	Bolari – Gombe chemist	0.8	0.8
37	Abubakar memorial pr sch – Y/guruza	0.6	1.3
38	Army barrack - Abubakar memorial pr	1.6	2.1
39	Gombe High School – U /church	1.12	1.12
40	Abuja quarters – Army barrack	0.15	0.15
41	GSWC – Army barrack	0.15	0.15
42	GRA – GSWC	2.3	1.3
43	New GRA – Police commissioner’s qt	2.1	2.4
44	Police commissioner’s quarter – ECWA Good news	1.0	1.0
45	Orji quarters – GSWC	3.1	2.1
46	Buhari estate – GRA Road	0.8	1.0
47	Bamusa – Army Barrack	2.35	2.56
48	Bogo – Manawashi	4.4	4.3
49	GSADP Quarters - Manawashi	4.92	4.65
50	Pantami police station – GSADP	0.8	0.8
51	Borehole NO. 94/Manawashi –Madaki	2.2	1.6
52	Buhari estate – Borehole No. 94	2.65	2.87
53	Masina – borehole No 94	1.05	1.0
54	Duniya earth dam – Borehole No 94	3.85	3.4
55	Riyad – Burunde	4.20	3.8
56	Hammad Kafi – Riyad	1.65	1.9
57	Wuro Briji – Riyad	3.4	2.8
58	Hammad Kafi – Wuro Briji	1.92	2.6
59	Duniya earth dam – Wuro Briji	4.25	3.78
	Total	121.50	131.02

Source: Gombe State Ministry of Water Resources and Environment (2003) and Field work 201

2.1.1 Spatial Distribution of Gully / Stream Orders

The spatial distribution of gully/ streams orders of the study area was extracted from the satellite image. The first order, second, third, fourth and fifth orders are the tributary that contributes to the main gully channel (sixth order) which is less dominant. The analysis revealed that there were 615 first order gullies representing 62% second order has 173 gullies or 18%, third order gullies has 89 in number and represent 12%, the fourth order has a total of 51gullies in number representing 5%, the fifth order consist of 30 gullies or 2% and the sixth order number which is the main gully has 11 in number representing 1.0% respectively. were the main gullies spread across the study area (Fig. 4). The sixth, fifth and fourth orders are the main stream channel (gullies) which tends to dominate the north-western part with their head incision towards the north eastern parts of the metropolis. This is due to the effect of the topography of over 400m above sea level dominating the western parts of the study area.

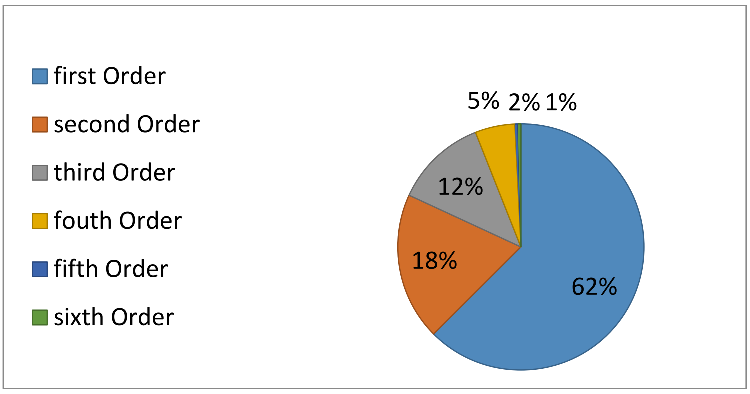

Figure 4: Spatial distribution of gully orders in Gombe Town. Source: GIS Analysis 2016

The first and second order Gullies /stream constituted the most spatially distributed (Table 2) and the most hazardous environmental problems threatening lives, infrastructural development and generally hindering the physical expansion of the town. Furthermore since there are so many governments find it very difficult to control these gullies, hence each rainy season gullies continue to increased in number and size.

Table 2: Distribution of Gully orders Densities in Gombe Town

	Sampled Quarters/ wards						
Gully orders	Fed. Lowcost/ FCE (T) - Arawa/ M/Inna	Shamaki– GSU Y/Gana/ Dawaki/ Bajoga	Kumbi Kumbiya/ Bolari. J/Fari	GRA-Pantami-Madaki-Doma	Total	Mean Total	% Total
1st order	157.99	151.63	159.01	145.95	614.58	153.64	62
2nd order	49.00	42.00	43.00	39.00	173.00	43.25	18
3rd order	30.57	17.82	24.22	15.89	88.50	22.12	12
4th order	13.21	16.08	13.60	7.80	50.68	12.67	5
5th order	0.96	9.86	6.92	11.54	29.29	7.32	2
6th order	1.03	1.47	0.50	8.20	11.20	2.80	1
TOTAL	252.75	238.86	247.26	228.38	967.25	241.81	100

Source: GIS analysis/field work 2016

Table 3: Length of Gullies Orders of Sample Wards each

	Length of gullies(km)				
Orders of stream	Fed. Lowcost/ FCE (T) - Arawa/ M/Inna	Shamaki– GSU Y/Gana/ Dawaki/ Bajoga	Kumbi Kumbiya/ Bolari. J/Fari	GRA-Pantami-Madaki- Doma	Total
1st order	10.2	9.5	6.2	4.5	30.4
2nd order	2.9	5.8	5.6	6.3	20.8
3rd order	1.16	9.0	2.35	4.8	17.31
4th order	5.9	2.3	5.5	9.36	23.0
5th order	4.3	5.3	4.3	4.2	18.1
6th order	1.51	12	0.02	8.0	20.35
Total	25.96	43.9	23.97	37.16	131.02

Source: GIS analysis/Field work, 2016.

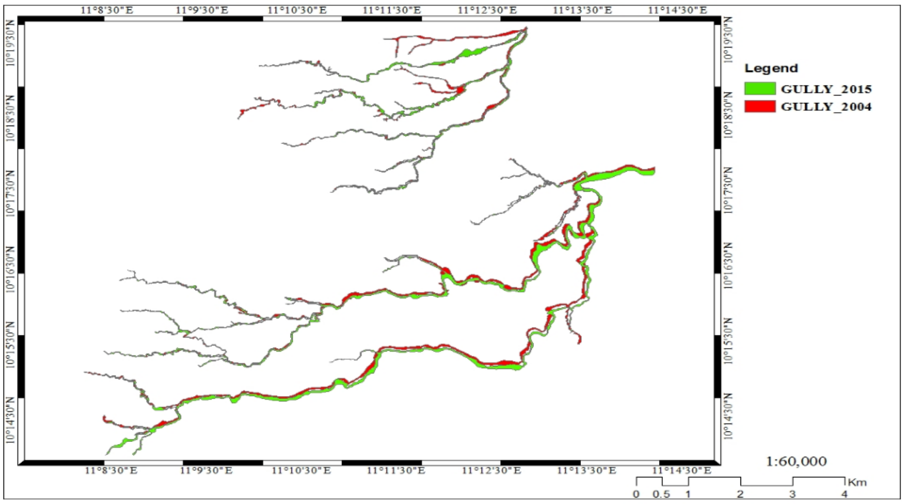

Figure 5: Overlay result of the 2004 and 2015 images of digitized Gully erosion.
Source: GIS analysis/Field work 2015

Using manual digitizing technique and ground truth very small gullies are easily detected visually and mapped thus providing the most accurate results that can be utilized as reference data. The result is differentiated by **green** and **red** color indicating gully extent as at 2004 and that of 2015 (Fig 5). Previous studies conducted shows that the total length of gully within the metropolis was about 121.5km, out of this only 5.6km in length have been controlled while 7.62km have been partially controlled leaving about 107.3km still uncontrolled, SEEDS (2006). The 2015 analysis from satellite image (Quick birds) revealed a total of 131.02 km increase gully lengths despite various control measure adopted by governments and residents. This is attributed the hydrological, topographical, geotechnical, soil and demographic factors.

5.2 Types of Spatial Distribution of Gully erosion Control Measures

2.1.2 Engineering Methods

This is the most effective and costly control method of gully erosion in the study area when best practice is adopted and when the full length is executed. Table 4 shows that out of the 131.02 km length of gully erosion inventory in Gombe town 2015 only 35.92 km length has been controlled under engineering method representing 27.2 %. Comparing the 2003 estimates of 13.22 km, there has been improvement I pn engineering control methods over the years.

Table 4: Spatial Distribution of Gully Erosion Control Measure Types (Length) in Gombe Town.

S/No	Name of Gully Sites	Types of control measures (Length in Kilimetres)			
		Engineering	Vegetation	Stone wall	Uncontrolled length
1	FCE (T) – Arawa	-	0.5	-	11.84
2	Mallam Inna – Gombe Hill	-	0.8	-	3.8
3	Mallam Inna – Arawa	-	0.2	-	2.65
4	Arabic T. C- Mallam Inna	-	-	-	3.54
5	Railway – Mallam Inna	-	-	-	1.0
6	GSU - Railway	-	0.5	-	1.0
7	FCE (T) staff school – Arabic TC	-	-	-	4.3
8	Musaba clinic – Tudun wada	1.0	-	-	0.9
9	Ministry of Agric –Tudunwada	1.1	-	-	-
10	Federal lowcost – Dukku motor park	0.8	-	-	-
11	Liman Pri Sch – Mallam Inna	-	-	-	0.8
12	Sabon Fegge – Railway	-	0.6	0.3	2.3
13	Govt comp sc Sch – former GSEMA	-	-	-	3.4
14	Railway – Gandu day SC School	1	-	-	0.5
15	Railway - Police barrack	1.2	-	-	0.5
16	Herwagana – Gombe hill	1.5	-	-	1.6
17	Bubayero – Herwagana	1.0	-	-	-
18	Dawaki – Herwagana	0.7	-	-	-
19	Gombe Line park – Central pr Sch	0.85	-	-	-
20	Old grave yard – Bubayero pr sch	2	-	-	0.3
21	Federal Lowcost – old grave yard	2.0	-	-	-
22	State secretariat – old grave yard	1.43	-	-	1.0
23	Federal lowcost – Bubayero pr Sch	1.0	-	-	-
24	Jallo waziri pr sch – Kcc Computer	0.55	-	-	-
25	Govt SC Sec sch – Fed lowcost	-	-	-	0.35
26	Railway – AYU Quary	-	-	-	1.2
27	Bogo – Doma	0.5	2	-	2.1
28	J/Fari – Yelenguruza	4	-	-	0.3
29	Shongo estate-Civil service com	2.0	-	-	2.4
30	Ashaka road – Civil service com	-	-	-	2.29
31	Ahmad Gombe pr sch – J/Fari	0.36	-	-	1.0
32	Ministry of works – J/Fari	0.55	-	-	-
33	Liberty – J/Fari	0.45	-	-	-
34	Gombe Int Pr Sch – J/ Fari	2.23	-	-	-
35	Miyetti cinema – Gombe Int sch	0.5	-	-	-
36	Bolari – Gombe chemist	0.8	-	-	-
37	Abubakar memorial pr sch – Yelenguruza	-	-	-	1.3
38	Army barrack - Abubakar memorial pr sch	-	-	-	2.1
39	Gombe High School – U Cchurch	1.0	-	-	0.12
40	Abuja quarters – Army barrack	-	-	-	0.15
41	GSWC – Army barrack	-	-	-	1.3
42	GRA – GSWC	2.1	-	-	0.3
43	New GRA – Police commissioner’s quarter	-	-	-	2.2
44	Police commissioner’s quarter – ECWA Good news	1.0	-	-	-
45	Orji quarters – GSWC	2.1	-	-	-
46	Buhari estate – GRA Road	1.0	-	-	-
47	Bamusa – Army Barrack	-	-	-	2.56
48	Bogo – Manawashi	-	0.5	-	3.8
49	GSADP Quarters - Manawashi	1.2	-	-	3.45
50	Pantami police station – GSADP	-	-	-	0.8
51	Borehole NO. 94 – Manawashi – Madaki	-	-	-	1.6
52	Buhari estate – Borehole No. 94	-	-	-	2.87

53	Masina – borehole No 94	-	-	-	1.0
54	Duniya earth dam – Borehole No 94	-	-	-	3.4
55	Riyad – Burunde	-	-	-	3.8
56	Hammad Kafi – Riyad	-	-	-	1.9
57	Wuro Briji – Riyad	-	-	-	2.8
58	Hammad Kafi – Wuro Briji	-	-	-	2.6
59	Duniya earth dam – Wuro Briji	-	-	-	3.78
	Total	35.92	5.1	0.3	90.94

Source: Field work, 2015

Plate I: Engineering control measure in Pantami ward (stadium) (N 10^{0}16′30.1″,E 011^{0}10 .02.5)

Plate II: Vegetative control meas1ure (Pantami ward, N10^{0}16^{1}30.1^{1}, E11^{0}10^{1}02.5^{11})

Plate III: Stonewall Control measure (Tundu Wada ward, N 10018.6451, E11 11.5471)

Plate IV: Uncontrolled gully Gully erosion (Arawa, Shamaki ward N10^{0}18^{1}37.8^{11} E11^{0}10^{1}43.5^{11})

Source: Field work, 2016.

2.1.3 Vegetation Method

The main reason for this success is connected to street/ roads construction which are also accompanied by construction of drainages more especially in Federal lowcost, Kumbiya Kumbiya, Dawaki, Jagada Fari, and shongo estate among others. Table 4 shows only 5.1 km length of vegetation used in gully erosion control measures out of the total 35.92 km length of the three methods of control measures under study, representing 14.19% and 3.89% of the total lengths of gullies in the study area. The main type of vegetation used is that of *paniculatu / Pitadeniastrum africanum* (kasha kori). This specie of plant is very effective in controlling gully erosion, as it is prone to dryness, survive throughout year, numerous and fine roots density within 0 – 60 cm soil depth, not palatable for animals, affordable and accessible. Unlike engineering method the use of vegetation is cheaper and very fast in stabilizing gully erosion corridors. Most of the areas where vegetation is used are found in low income and sub urban areas where gully erosion menace is devastating and government intervention in terms of engineering method hardly reached. Individual or community efforts contributed to the 5.1 km length of vegetation planted in affected gully erosion corridors.

2.1.4 Stone wall method

Stone wall like engineering method requires capital and technical known how, hence individual or community rarely adopt this method. Table 4 revealed no substantial length (300m) of stone wall used in controlling gully erosion in the study area. However, Gombe State Ministry of Water Resources and Environment (2003) reported that stone wall was the earlier method adopted in controlling gully erosion, but most of it has collapsed hence government decision replacing them with engineering method.

6 Summary and Conclusion

Result of the study revealed that most of the previous uncontrolled or partially checked gullies have increased in length to 131.02 km as against the 121.50 km in 2003. This represents an increase of 9.72 km (7.42 %) over the 13 years period or about 75 metres annual increase in gully length. The analysis further revealed that there were 615 first order gullies representing 62% second order has 173 gullies or 18%, third order gullies has 89 in number and represent 12%, the fourth order has a total of 51gullies in number representing 5%, the fifth order consist of 30 gullies or 2% and the sixth order number which is the main gully has 11 in number representing 1.0% respectively. Out of the 131.02 km length of gully erosion inventory in Gombe town 2015 only 35.92 km length has been controlled under engineering method representing 87 %. On the other hand 5.1 km length of vegetation used in gully erosion control measures out of the total 41.32 km length of the three methods of control measures under study.

Gully erosion in Gombe town will continue to do more havoc as long as the various landuses that are in conflict with environment and holistic approach to erosion control measures are not taken. While engineering method of gully erosion control is the best, it is expensive and costly and required technical known how, therefore it is suggested that residents and other stake holders can contribute through planting and rising of vegetation along the gully corridors. Kashe kwari for example is very effective in gully erosion control as it is affordable, accessible, survive and thrive well in the long dry season, not palatable to animals and when matured can be harvested as fuelwood more especially the vulnerable people in the town.

The loss of lands due to gully erosion and the increasing demand made on the land by agriculture, urban growth, industrialization and other human activities make the need for integrated landscape planning urgent.

Proper land use and watershed management can be used to reduce surface water runoff and control infiltration in order to dampen erosive forces and reduce the erodibility of soils. However, lack of awareness about the cause of the problem is very evident within the community. Many households in the community either do not know the cumulative effect of the lack of proper drainage systems or do not care because there are no direct and immediate repercussions for their poor land management. There is a lack of legislative frameworks to ensure that households refrain from practices that cause gully erosion, and enable these communities enact enforcement mechanisms. In addition, information on the causes of gully erosion and how it can be prevented are scarce. Many of these communities are not aware of the major causes of gully erosion and how it can be prevented, or how their actions are contributing to gully formation but if they are enlighten on the adverse effect of their contribution as well as the significant direct effect of gully erosion then they can have a cautions mind of how to help in monitoring, and even prevent the gully. Below is an efficacy model that should be added to the above in other to bridge the gap for the controlling of gully in the study area.

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