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Exploring Challenges in Applying Foundation and Generative Models in AI

Ayse Kok Arslan

Abstract:
This study provides a comprehensive review on generative models, and basic components both from the perspective of unimodality and multimodality. The analysis aims to distinguish contemporary generative AI models from their predecessors. After providing a brief historical background the study discusses the recent applications of generative AI models, commonly used techniques in AIGC, and addresses concerns surrounding trustworthiness and responsibility in the field. Finally, it explores open problems and future directions for AIGC, highlighting potential avenues for innovation and progress.

INTRODUCTION

In recent years, Artificial Intelligence Generated Content (AIGC) has gained much attention beyond the computer science community.

AIGC refers to content that is generated using advanced Generative AI (GAI) techniques, as opposed to being created by human authors, which can automate the creation of large amounts of content in a short amount of time.

Generally, GAI models can be categorized into two types: unimodal models and multimodal models (Fig. 1.0). Unimodal models receive instructions from the same modality as the generated content modality, whereas multimodal models accept cross-modal instructions and produce results of different modalities.

Technically, AIGC refers to, given human instructions which could help teach and guide the model to complete the task, utilizing GAI algorithms to generate content that satisfies the instruction.

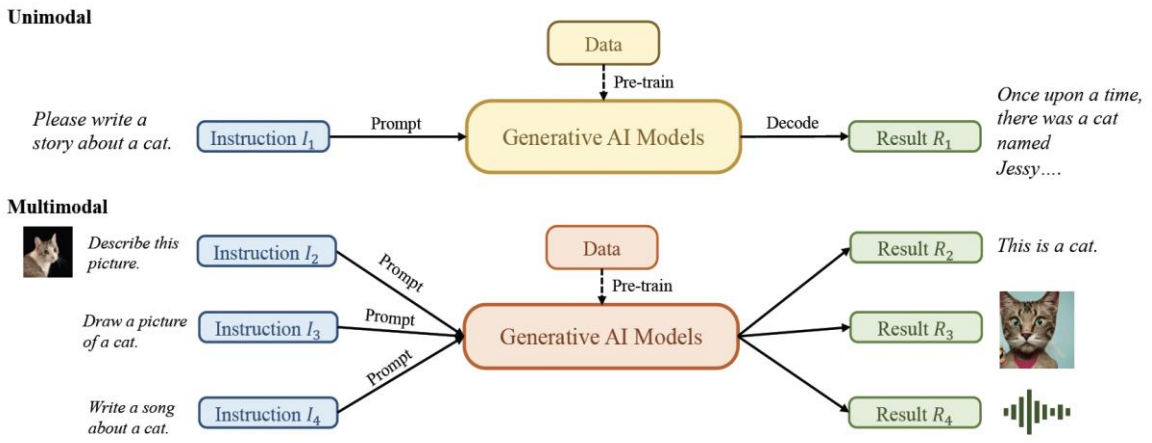


Fig. 1. Overview of AIGC (Credit: Yenala et al (2019))

By combining these advancements, models have made significant progress in AIGC tasks and have been adopted in various industries, including art [14], advertising [15], and education [16]. In the near future, AIGC will continue to be a significant area of research in machine learning. It is therefore crucial to conduct an extensive review of past research and identify the open problems in this field.

This study focuses on the core technologies and applications in the field of AIGC. The primary objective is to provide readers with a comprehensive understanding of recent developments and future challenges in generative AI.

BACKGROUND OF GENERATIVE AI

Generative models have a long history in artificial intelligence, dating back to the 1950s with the development of Hidden Markov Models (HMMs) [20] and Gaussian Mixture Models (GMMs) [21]. These models generated sequential data such as speech and time series. However, it wasn't until the advent of deep learning that generative models saw significant improvements in performance.

In early years of deep generative models, different areas do not have much overlap in general. In natural language processing (NLP), a traditional method to generate sentences is to learn word distribution using N-gram language modeling [22] and then search for the best sequence. However, this method cannot effectively adapt to long sentences. To solve this problem, recurrent neural networks (RNNs) [23] were later introduced for language modeling tasks, allowing for modeling relatively long dependency.

This was followed by the development of Long Short-Term Memory (LSTM) [24] and Gated Recurrent Unit (GRU) [25], which leveraged gating mechanism to control memory during training. These methods are capable of attending to around 200 tokens in a sample [26], which marks a significant improvement compared to N-gram language models.

In recent years, researchers have also begun to introduce new techniques based on these models. For instance, in NLP, instead of fine-tuning, people sometimes prefer few-shot prompting [38], which refers to including a few examples selected from the dataset in the prompt, to help the model better understand task requirements. In visual language, researchers often combine modality-specific models with self-supervised contrastive learning objectives to provide more robust representations.

In the future, as AIGC becomes increasingly important, more and more technologies shall be introduced, empowering this area with vitality.

FOUNDATIONS FOR AIGC

This section introduces important models such as foundation and generative models in AIGC.

Foundation Model

Transformer:

Transformer is the backbone architecture for many state-of-the-art models and is mainly based on a self-attention mechanism that allows the model to attend to different parts in an input sequence. Transformer consists of an encoder and a decoder. The encoder takes in the input

sequence and generates hidden representations, while the decoder takes in the hidden representation and generates output sequence.

Each layer of the encoder and decoder consists of a multi-head attention and a feed-forward neural network. The multi-head attention is the core component of Transformer, which learns to assign different weights to tokens according their relevance.

***Pre-trained Language Models*:**
Generally, these transformers based pre-trained language models can be commonly classified into two types based on their training tasks: autoregressive language modeling and masked language modeling [41].

Given a sentence, which is composed of several tokens, the objective of masked language modeling, e.g., BERT [42] and RoBERTa [43], refers to predicting the probability of a masked token given context information. The most notable example of masked language modeling is BERT [42], which includes masked language modeling and next sentence prediction tasks.

Reinforcement Learning from Human Feedback:
Despite being trained on large-scale data, the AIGC may not always produce output that aligns with the user's intent, which includes considerations of usefulness and truthfulness. In order to better align AIGC output with human preferences, reinforcement learning from human feedback (RLHF) has been applied to fine-tune models in various applications such as Sparrow, InstructGPT, and ChatGPT [10, 46]. Typically, the whole pipeline of RLHF includes the following three steps: pre-training, reward learning, and fine-tuning with reinforcement learning.

Generative Models
Unimodal Models:
Generative Language Models:
Generative language models (GLMs) are a type of NLP models that are trained to generate readable human language based on patterns and structures in input data that they have been exposed to. These models can be used for a wide range of NLP tasks such as dialogue systems [58], translation [59] and question answering [60].

Recently, the use of pre-trained language models has emerged as the prevailing technique in the domain of NLP. Generally, current state-of-the-art pre-trained language models could be categorized as masked language models (encoders), autoregressive language models (decoders) and encoder-decoder language models.

Decoder models are widely used for text generation, while encoder models are mainly applied to classification tasks. By combining the strengths of both structures, encoder-decoder models can leverage both context information and autoregressive properties to improve performance across a variety of tasks.

Multimodal Models:
The goal of multimodal generation is to learn a model that generates raw modalities by learning the multimodal connection and interaction from data [7]. This connection and interaction between modalities can sometimes be very intricate, which makes the multimodal representation space hard to learn compared to the unimodal one. However, with the emergence of the powerful

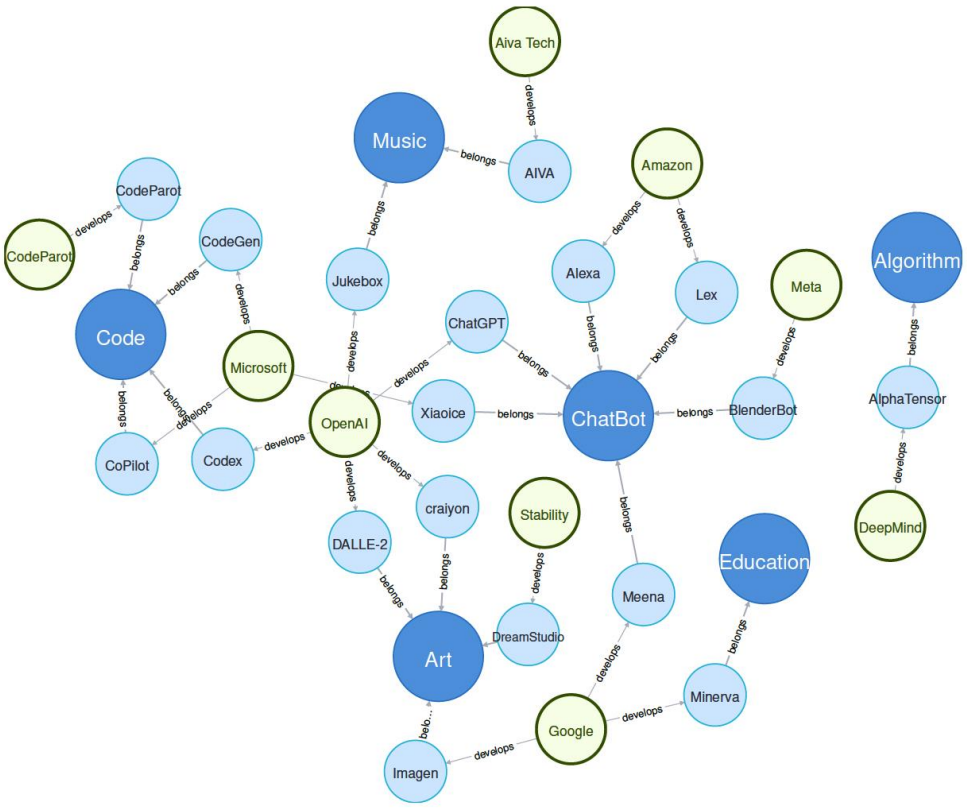
modality-specific foundation architectures mentioned in previous sections, a growing number of methods are proposed in response to this challenge.

Vision Language Generation:
The encoder-decoder architecture is a widely used framework for solving unimodal generation problems in computer vision and natural language processing. The encoder is responsible for learning a contextualized representation of the input data, while the decoder is used to generate raw modalities that reflect cross-modal interactions, structure, and coherence in the representation.

Vision Language Encoders:
Recently, the development of encoders for single modalities has advanced significantly, leading to the question of how to learn contextualized representations from multiple modalities. A common way to do this is to combine modality-specific encoders using a fusion function and then leverage multiple pre-training tasks to align the representation space [37, 134, 135]. Generally. these encoder models could be separated into two categories, concatenated encoders and cross-aligned encoders [7].

APPLICATIONS

ChatBot
A chatbot is a computer program designed to simulate conversation with human users through text-based interfaces. Chatbots normally use language models to understand and respond to user queries and inputs in a conversational manner. They can be programmed to perform a wide range of tasks, for example, providing customer support and answering frequently asked questions.



Art

AI art generation refers to using computer algorithms to create original works of art. These algorithms are trained on large datasets of existing artwork and use machine learning techniques to generate new pieces that mimic the styles and techniques of famous artists or explore new artistic styles.

Music

Deep music generation refers to the use of deep learning techniques and artificial intelligence algorithms to generate novel and original pieces of music. A prominent approach is to produce a symbolic representation of the music in the form of a piano roll. This approach entails specifying the timing, pitch, velocity, and instrument for each note to be played.

Code

AI-based programming systems generally aim for tasks including code completion, source code to pseudo-code mapping, program repair, API sequence prediction, user feedback, and natural language to code generation.

It can be fine-tuned for various code generation tasks such as code completion, summary, or translation based on a vast amount of source code data.

One unique feature is the scaffolding strategy which splits complicated tasks into smaller and manageable steps to help students gradually build their coding skills.

Education

AIGC has the potential to achieve significant advancements in education by leveraging multimodality data, for example, tutorial videos, academic papers, and other high-quality information, thereby improving the personalized education experience.

On the academic side, Google Research introduced Minerva [207], which is built upon PaLM general language models [209] and an additional science-and-math-focused dataset, to solve college-level multi-step quantitative tasks, covering algebra, probability, physics, number theory, precalculus, geometry, biology, electric engineering, chemistry, astronomy, and machine learning.

Given these applications, the increasing model footprint and complexity, as well as the cost and resources required for training and deployment, pose challenges for practical deployment in the real world. The core challenge is efficiency, which can be broken it down as follows:

- ***Inference Efficiency:*** This is concerned with the practical considerations of deploying a model for inference, i.e., computing the model's outputs for a given input. Inference efficiency is mostly related to the model's size, speed, and resource consumption (e.g., disk and RAM usage) during inference.
- ***Training Efficiency:*** This covers factors that affect the speed and resource requirements of training a model, such as training time, memory footprint, and scalability across multiple applications.

An important technique to overcome issues in efficiency is 'prompt learning' which is a relatively new concept that proposed in recent years within the context of pre-trained large language models. Previously, to make a prediction y given input x, the goal of traditional supervised

learning is to find a language model that predicts the probability $P(y|x)$. With prompt learning, the goal becomes finding a template x' that directly predicts the probability $P(y|x')$ [211].

Normally, prompt learning will freeze the language model and directly perform few-shot or zero-shot learning on it. This enables the language models to be pre-trained on large amount of raw text data and be adapted to new domains without tuning it again. Hence, prompt learning could help save much time and efforts.

Traditional Prompt Learning

The process of utilizing prompt learning with a language model can be divided into two main stages: prompt engineering and answer engineering.

- ***Prompt Engineering:*** In general, there are two commonly used forms of prompt engineering: Discrete prompt and continuous prompt. Discrete prompts are typically manually designed by humans for specific tasks, while continuous prompts are added to the input embeddings to convey task-specific information.
- ***Answer Engineering:*** After the task has been reformulated, the answer generated by the language model based on the provided prompt needs to be mapped to the ground truth space. There are different paradigms for answering engineering, including discrete search space and continuous search space.

In addition to single-prompt learning methods, there are also multi-prompt methods. These approaches primarily focus on ensembling multiple prompts together as input during inference to improve prediction robustness, which is more effective than relying on a single prompt.

Another approach to multi-prompt learning is prompt augmentation, which aims to assist the model in answering questions by providing additional prompts that have already been answered.

In-Context Learning

This approach is a subset of prompt learning and involves using a pre-trained language model as the backbone, along with adding a few input-label demonstration pairs and instructions to the prompt.

SECURITY AND PRIVACY IN AIGC

While AIGC has the potential to be incredibly useful in many different applications, it also raises significant concerns about security and privacy.

Security

Factuality:

Systematic definitions of truthfulness standards and approaches for governing AI-generated content were proposed in Truthful AI [24]. The standard proposed by Truthful AI aims to avoid "negligent falsehoods" and explicitly train AI systems to be truthful via curated datasets and human interaction.

Based on GPT-3, WebGPT [25] proposed a humanoid prototype that models the AI answering process into web searching and evidence-composing phrases. Since the model is trained to cite its sources, the factual accuracy of AI-generated content is significantly improved in multiple benchmark datasets [26, 27].

Toxicity:

Besides utility, it is important for AI-generated content (AIGC) to be helpful, harmless, unbiased, and non-toxic. Extensive research has been conducted on the potential harm caused by deployed models [229–231], which can include biased outputs [232, 233], stereotypes [234], and misinformation [25].

To address this issue of toxicity in the language domain, OpenAI proposes InstructGPT [10], which aligns language models with human preferences by using human feedback as a reward signal to fine-tune the models, ensuring more relevant and safe responses. Concurrently, Google proposes LaMDA [26], a family of neural language models specialized for safe and factual dialog by leveraging fine-tuning and external knowledge sources.

Privacy

Membership Inference:

The goal of the membership inference attack (MIA) is to determine whether an image x belongs to the set of training data. Wu et al. [238] investigated the membership leakage in text-to-image (diffusion-based and sequence-to-sequence-based) generation models under realistic black-box settings. Specifically, three kinds of intuitions including quality, reconstruction error, and faithfulness are considered to design the attack algorithms.

***Data Extraction*:**

The objective of a data extraction attack is to retrieve an image from the set of training data, denoted as $x \in D$. The attack can be considered a success if the attacker is able to obtain an image $\hat{x}$ that closely resembles image $x \in D$.

Compared to the membership inference attack, the data extraction attack poses stronger privacy risks to the model. The feasibility of such an attack might be due to the memorization property of large-scale models [243], in which they turn to memorize parts of their training data.

OPEN PROBLEMS AND FUTURE DIRECTIONS

Many fundamental challenges to developing a high-quality model capable of performing well in real world applications still exist. For example, it is now increasingly well-understood that large language models trained on unlabeled datasets will learn to imitate patterns and biases inherent in their training sets [10]. Such biases can be hard to detect since they manifest in a wide variety of subtle ways. For example, the axes of marginalization differ greatly across geo-cultural contexts, and how they manifest in pre-trained language models is an under-studied area [11].

Known approaches to mitigate undesirable statistical biases in generative language models include attempts to filter pre-training data, train separate filtering models, create control codes to condition generation, and fine-tuning models. While these efforts are important, it is critical to also consider the downstream applications and the socio-technical ecosystems where they will be deployed when measuring the impact of these efforts in mitigating harm. For example, bias mitigations in certain contexts might have counter-intuitive impacts in other geo-cultural contexts [10].

The field of algorithmic bias measurement and mitigation is still growing and evolving rapidly, so it will be important to continue to explore novel avenues of research to ensure the safety of dialog agents Future work should explore the benefits of greater coordination across the research

community and civil society in the creation of benchmarks and canonical evaluation datasets to test for harmful and unsafe content.

Another potential area of exploration is to study how different applications may warrant distinct levels of safety, quality, and groundedness based on the risk/benefit tradeoffs of these individual applications.

It should also be taken into account that various traits measured for safety objectives depend heavily on socio-cultural contexts. Therefore, any meaningful measure of safety should take into account the societal context where the system will be used, employing a "participatory finetuning" approach that brings relevant communities into the human-centered data collection and curation processes.

Another challenge in GAI models relates to reasoning which is a crucial component of human intelligence that enables us to draw inferences, make decisions, and solve complex problems. However, even trained with large scale dataset, sometimes GAI models could still fail at common sense reasoning tasks [256, 257]. Recently, more and more researchers began to focus on this problem.

Chain-of-thought (CoT) prompting [256] is a promising solution to the challenge of reasoning in generative AI models. It is designed to enhance the ability of large language models to learn about logical reasoning in the context of question answering. By explaining the logical reasoning process that human-beings use to arrive at answers to models, they can follow the same road that humans take in processing their reasoning.

Model training is always limited by compute budget, available dataset and model size. As the size of pretraining models increases, the time and resources required for training also increases significantly. This poses a challenge for researchers and organizations that seek to utilize large-scale pretraining for various tasks, such as natural language understanding, computer vision, and speech recognition.

Another issue pertains to the efficacy of pretraining with large-scale datasets, which may not yield optimal results if experimental hyperparameters, such as model size and data volume, are not thoughtfully designed. As such, suboptimal hyperparameters can result in wasteful resource consumption and the failure to achieve desired outcomes through further training.

AI models can inadvertently perpetuate or amplify existing societal biases, particularly if the training data used to develop the models are themselves biased. This can have significant negative consequences, such as perpetuating discrimination and inequities in areas such as hiring, loan approvals, and criminal justice.

Overall, while AI-generated content holds significant promise in various domains, it is crucial to address these concerns to ensure that its use is responsible and beneficial for society as a whole.

CONCLUSION

This study provides a comprehensive overview of the history and recent advancements in AIGC, with a particular focus on both unimodality and multimodality generative models.

The primary objective is to provide readers with a comprehensive understanding of recent developments and future challenges in generative AI. The analysis of the general framework of AI generation aims to distinguish contemporary generative AI models from their predecessors.

Hopefully, this study will aid readers in gaining deeper insights into this field.

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The Gauss's, Theorema Egregium

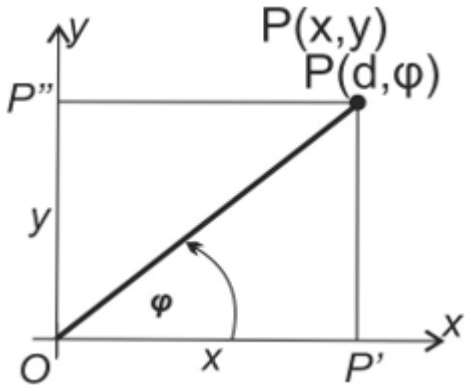
Peter G. Gyarmati

Abstract:
To understand Gauss's theory about the non-Euclidean geometry we have to reestablish some definitions of the coordinate system, and introduce the so-called Gaussian coordinates. We show here that the two points distances as a postulate can establish a metric geometry. If we can show the validity of this postulate on any surface than it has his geometry, and not necessarily Euclidean. Gauss showed in The Theorema Egregium that a surface might have such attributes. The different geometries of the regular surfaces written here are Euclidean, spherical, and hyperbolic. This theorem presented in 1827. (Based on the lectures of K. Lanczos: Department of Physical Sciences and Applied Mathematics, North Carolina State University, Raleigh, 1968.) The importance of this lecture is to make clear and understandable by using Gausss's theorem how and why the physicians must use non-Euclidean geometry.

ANTECEDENTS

A Postulate of The Coordinate System Establish the Metric Geometry

The Cartesian coordinate system applicable for the full Euclidean geometry and every point is metric: the distance between any two points determined by the algebraic way. In other words, the Cartesian coordinate system and all of its correct conversion are metric spaces and exist such a portion, which is fully met with the Euclidean geometry [3]. Gauss showed that the full geometry could be constructed by only one postulate.



Interpretation

The distance between any two points AB is: $s^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2$.
Gauss showed that the Euclidean geometry can be deduced from this postulate.

We study here only the structure and validity of the coordinate system based on this postulate.

Axes:
Straight lines, which intersect each other at the origin and perpendicular pairwise. Such a line, for example, the number line with the ordered set of the real numbers. Two perpendicular axes form

a plane, which the privileged point is the origin *O*, then we call them respectively, *x-axis* or abscissa and *y-axis* or ordinate.

Coordinates:
Distances measured from the axes, in geometric terms a perpendicular projection of the point *P* to the axes. The distance is the length of this section.

The point now a pair: $P(x,y)$ $\left|x=\overline{PP"}=\overline{OP'};y=\overline{PP'}=\overline{OP"}\right.$

The relationship between the pair and the point is mutual: we can define *x and y* from the point *P*, or vice-versa get the *P* point from *x and y*.

Consequences:
1. We may replace all geometric constructions with algebraic operations.
2. We may replace any algebraic operation for an *(x,y)* to geometric construction.

Angle*:*
Gives the direction of the straight line, that goes through O and P points, and we usually measure it from the *x*-axis. Geometrically the inclination of two lines lays both on origin, i.e. the angle between them. Algebraically the ratio of the *P* coordinates: $tg\alpha=\frac{y}{x}\rightarrow\alpha=arctg\frac{y}{x}$ also called *tangent*, whereas *POP'* is a right triangle (the angle at the origin).

Straight-Line*:*
We can get the straight-line equation if we use $\frac{y}{x}=tg\alpha=m$ for a point *P* lay on a line: $y=mx$, which means that any solutions of this equation – the *(x,y)* pairs - are on the line. If the line does not cross the origin, then the equation altered to: $y=mx+y_0$, where y_0 the cross point with the *y*-axis, or algebraically the equation's solution for *x=o*.

We show here that the algebraic expression $Ax+By+C=0$ - a linear equation with two unknown quantities - all possible solution's lay on a straight line and also describe all its points.

The $y=mx+y_0$ straight-line lays on two points: $(0,y_0)$ and $(x_0,0)$ which intersects the axes. So, from the two equations $m=tg\frac{y_0}{x_0}$ and $y=\frac{y_0}{x_0}x+y_0$, by making common denominator $y=\frac{y_0x+y_0x_0}{x_0}$ and reduce to zero, we get: $y_0x-x_0y+x_0y_0=0$. Now let us use these notions: $A=y_0;B=-x_0;C=x_0y_0$ (see the meaning of the negative value on the figure: if $y_0>0$, then $x_0<0$ and vice versa). Thus, we showed that the $Ax+By+C=0$ expression is the coordinate-geometry form of the straight line. Any points on the line are solutions of the equation and only those.

Circle:
The definition of the circle immediately gives its equation: a geometric location of all points, which lay in the same distance from a common point. So, using the distance postulate: $r^2=(x-x_0)^2+(y-y_0)^2$, where *r* the radius and (x_0,y_0) is the origin.

Arc:
A piece of the circle line. The angle of the full circle is *2π*, and the circumference of a circle is *2rπ*, then proportionally the AB arc has an angle φ_{AB} and so $\varphi = \frac{AB}{r}$, and its length $AB = \varphi r$.

Now we have shown that the basic elements of the Euclidean geometry fully revealed in a Cartesian coordinate system.

***Infinitesimal Distance**:*
for the sake of generalization of the space concept, we satisfy to study the immediate surrounding of a point, so we interpret the distance between (x, y) and $(x + \Delta x, y + \Delta y)$ where the Δ can be any small size, i.e., infinitesimal. Then using our only postulate, the distance: $ds^2 = dx^2 + dy^2$, because $x + dx - x = dx$ and $y + dy - y = dy$.

The derivate of the function $y = f(x)$ is: $f'(x) = \frac{dy}{dx} \rightarrow dy = f'(x)dx \rightarrow$ then $dy^2 = f'^2(x)dx^2$ and from these $ds^2 = dx^2 + f'^2(x)dx^2$. We have the distance by integration between the two points: $s = \int_A^B \sqrt{1 + f'^2(x)}dx$ if *s* minimal. Leaving the details of the reduction – requires variation computing - we arrive at the line equation: $Ax + By + C = 0$, which means, the smallest distance between two points is a straight-line segment. This refers to our geometric attitude. So, we proved that the postulate valid in the infinitesimal environment also.

***The Intersection of Two Lines**:*
Very interesting task to find the intersection of two lines.

Let us have these two lines:

$$e_1 : a_1x + b_1y + c_1 = 0 \text{ and } e_2 : a_2x + b_2y + c_2 = 0.$$

The *P* interception point is the common solution of the two equations, the *(x,y)* value that satisfies both equations. Leaving the reduction out we get: $x = \frac{b_1c_2 - b_2c_1}{a_1b_2 - a_2b_1}$ and $y = \frac{a_2c_1 - a_1c_2}{a_1b_2 - a_2b_1}$.

Consequently, the two lines always intersect each other if the determinant non-zero: $\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} \neq 0$.

If it where rather zero: $a_1b_2 - a_2b_1 = 0$, then $\frac{a_1}{a_2} = \frac{b_1}{b_2}$, which means the tangents are equal because $m_1 = \frac{a_1}{a_2}$ and $m_2 = \frac{b_1}{b_2}$. Thus, the two lines are parallel i.e., no common points.

Curve Line Coordinates
We arrived at beautiful results, then we continue with our imaginations, and we assume that the lines replaced by arbitrary curves like this: *x = f (t)* and *y = g (t),* where *f (t)* and *g (t)* is continuous function of variable *t*, and ought to be differentiable for infinitesimal use.

There have been examined already many curves geometrically – usually, each is special case - but we would like to arrive at a general solution by algebraic way. It is possible, as we did not attach any more condition, only the continuity and differentiability. Then in this way, we can determine the 'direction' of a curve and introduce the concept of 'curvature'.

The direction of a curve at any point is the gradient of the tangent line: $ds^2 = dx^2 + dy^2 \to 0$ drawn to that point. The direction changed from point to point: this is what we call: curvature. Now, draw a circle through three points of the curve – the best fitting circle – then the distance from its origin will be proportional to the curvature at that point. If we determine these origins for all points, we get another curve with ordinates: $\xi = \varphi(t)$, $\eta = \theta(t)$. This we call *evolute* of the original curve.

Gaussian Coordinates

As we have seen the geometric problems translated to algebraic ones by using, either orthogonal (x, y) or polar (r, φ) coordinates. Then their conversion: $x = r\cos\varphi\,;\, y = r\sin\varphi$ [3]. We also have seen the coordinate-lines dividing a plane into small quadrants.

Let's consider these generally, according to Gauss, and introduce the following general relations: $x = x(u,v)\,;\, y = y(u,v)$ which again have to be continuous and differentiable in the studying environment, and have also a non-zero determinant: $\begin{vmatrix} \frac{\delta x}{\delta u} & \frac{\delta x}{\delta v} \\ \frac{\delta y}{\delta u} & \frac{\delta y}{\delta v} \end{vmatrix} \neq 0$. Note that this not met at *r=o*, in the origin's environment.

The so introduced *(u,v)* pairs uniquely define the points of a surface. These referred to as Gaussian coordinates. The coordinate-lines drew according to *(u,v)* also divides the plane into small quadrants.

Now we have to show that the postulate also valid with the Gauss-coordinates. According to the determinant above: $dx = \frac{\delta x}{\delta u}du + \frac{\delta x}{\delta v}dv$; $dy = \frac{\delta y}{\delta u}du + \frac{\delta y}{\delta v}dv$ and by this the distance i.e., the postulate is

$$ds^2 = dx^2 + dy^2 = \left[\left(\frac{\delta x}{\delta u}\right)^2 + \left(\frac{\delta y}{\delta u}\right)^2\right]du^2 + \left[\left(\frac{\delta x}{\delta v}\right)^2 + \left(\frac{\delta y}{\delta v}\right)^2\right]dv^2 + 2\left(\frac{\delta x}{\delta u}\frac{\delta x}{\delta v} + \frac{\delta y}{\delta u}\frac{\delta y}{\delta v}\right)dudv$$

In the case of polar coordinates, the expression with the necessary reductions is: $ds^2 = dr^2 + r^2 d\varphi^2$. Now the arc, which is the shortest way between any two points *A*, *B* gives: $(a\cos\varphi)r + (b\sin\varphi)r + c = 0$. Therefore, this is the postulate!

Now we proved that in both, the Cartesian and the Gaussian coordinates - straight line, curve line or orthogonal and non-orthogonal – the distance postulate valid and describes the full geometry.

Now we may expand the here discussed two-dimensional space to any space if the postulate remains unchangeably valid in the resulting space. We call these spaces *metric-space* according to our modern conceptions, regardless of the number of dimensions.

In many cases, we will be satisfied if the conditions apply only in the immediate surroundings of a point in a space. Conversely, if any points in a space have such an environment by which a coordinate system interpreted, then the space is a *Euclidean topological space*.

Gauss's Non-Euclidean Idea

Gauss came to an interesting result when he had to perform measurements in a hilly area. Provided two sets of curves intersecting each other mutually, like the coordinate-lines. These are the already known *(u,v)* pairs. Now, if we place them into a three-dimensional orthogonal coordinate system then it is expressed this way $x = x(u,v)$; $y = y(u,v)$; $z = z(u,v)$, and the arc:

$$ds^2 = dx^2 + dy^2 + dz^2 .$$

Express the former with the latter:

$$dx = \frac{\delta x}{\delta u}du + \frac{\delta x}{\delta v}dv \text{ ; } dy = \frac{\delta y}{\delta u}du + \frac{\delta y}{\delta v}dv \text{ ; } dz = \frac{\delta z}{\delta u}du + \frac{\delta z}{\delta v}dv$$

and replace to the arc expression, then we get $ds^2 = Edu^2 + 2Fdudv + Gdv^2$, where

$$E = \left(\frac{\delta x}{\delta u}\right)^2 + \left(\frac{\delta y}{\delta u}\right)^2 + \left(\frac{\delta z}{\delta u}\right)^2 ;$$
$$F = \frac{\delta x}{\delta u}\frac{\delta x}{\delta v} + \frac{\delta y}{\delta u}\frac{\delta y}{\delta v} + \frac{\delta z}{\delta u}\frac{\delta z}{\delta v} ;$$
$$G = \left(\frac{\delta x}{\delta v}\right)^2 + \left(\frac{\delta y}{\delta v}\right)^2 + \left(\frac{\delta z}{\delta v}\right)^2 .$$

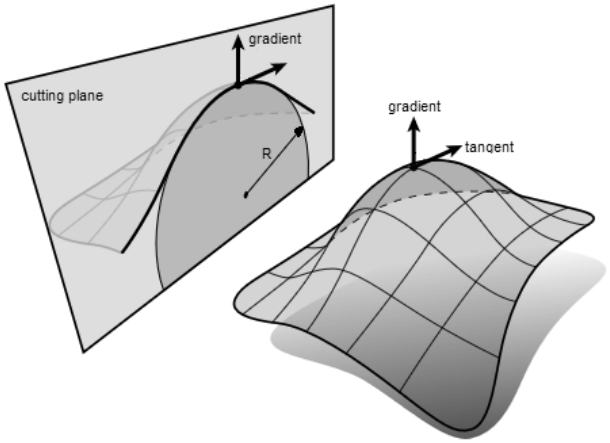
We come to an interesting result: the distance on the surface and in the space may have the same. Rather these points are on a curve on the surface and on a straight-line segment in the space. However, it can be true infinitesimally, as the two points are arbitrarily close to each other. This ds^2 is a limit and a common value in the space and on the surface. We got a different geometry, the *internal geometry of the surface*, where these shortest lines are straight. Moreover, it shall remain valid as long as we stay on the surface.

Therefore, Gauss showed that the internal geometry of a curve surface is uncontradictory and does not have to be the subject of the Euclidean postulates. If this surface is an ellipsoid, for example, then easy to understand that a triangle will incongruent for the move, either the sides or the angles will change. The consequences are that the space changes from point to point.

THE THEOREM EGREGIUM

The Curvature

In 1827, Gauss published the *Disquisitiones generales circa superficies of the curves*, - General studies of the Curved Surfaces [4] - and inside with a theorem that he signed as remarkable: *Theorem Egregium*.



This writing defined the curvature as follows:
Let given a surface, and construct the gradient of the tangent plane for a point *P*. Now we use a plane along the gradient, which will cut a plane-curve from the surface. If we move around this plane along the gradient as an axis, then in each step the cut of the plane-curve will be different. We get dissimilar radiuses and curvatures. However, each curvature will have a maximum then a minimum value, in the extreme positions of the rotating plane: radius R_1 *and* R_2. Let's call the reciprocals as *curvatures* and the extremes as *main curvatures*: $k_1 = \frac{1}{R_1}$ and $k_2 = \frac{1}{R_2}$. Of course, this may not be an internal property of the surface, since *the gradient is outside from the surface*. Therefore, the curvature is available only from a space that contains the surface.

Consider the product of the two *main curvature* $k = k_1 k_2 = \frac{1}{R_1 R_2}$.

Gauss came to the surprising conclusion, - which is not deducted here – that the value of *k* can get from *(E), (F), and (G).*

Then, this is notwithstanding an *internal property of the surface*, regardless of whether we defined externally. The value of *k* independent from the *(u,v)* coordinates since we constructed it with clear geometry. *So, k, the curvature is invariant in any Gaussian coordinate-system!*

The Property of k

Now examine the different values of *k.*

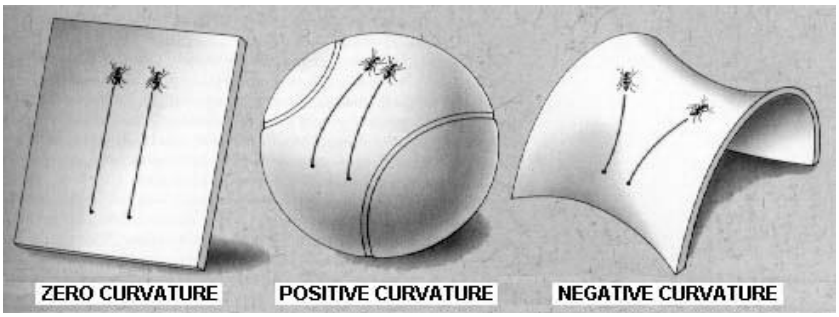
In general cases, the value of *k* constantly changes according to the surface, but let's examine the special cases:

- If *k=zero*, then the surface is a plane, become Euclidean;
- If *k=constant*, then the surface is even and so the forms on it may freely move without changes.

- The constant value either positive or negative:
- If the radiuses are on the same side – positive *k* - of the tangent - than the surface convex;
- If they are on different side, – negative k - then the surface saddle-shaped ie. in all directions move away from point *P*.

As we already mentioned, we are talking about, "even" surface, i.e., the curvature constant. We also did the necessary calculations. Then let us, have a unit size curvature, and then we come to the following terms. If

k = 1, then the geometry spherical: $ds^2 = du^2 + dv^2 \sin^2 u$
k = 0, then the geometry Euclidean: $ds^2 = du^2 + dv^2 u^2$
k =-1, then the geometry hyperbolic: $ds^2 = du^2 + dv^2 sh^2 u$



Different *k* values

Notice the simple differences between each distance and yet they open a quite different world. The *Euclidean Geometry* has the multiplier factor: u^2 , the *Spherical Geometry* has the: $\sin^2 u$, and the *Hyperbolic Geometry* has the: $sh^2 u$.

This is the beauty of mathematics.

Other Results

Gauss in this presentation came to the definition of the non-Euclidean geometries, having evidence about their existence and uncontradictory.

Gauss's investigations covered this field are little known, but we know his other result which leads to the sum of the angles in a triangle. This definition uses the calculation of the area of a triangle, which is a relationship between the area and the curvature. He came to the following: $\alpha + \beta + \gamma - \pi = \int k d\delta$, where the $d\delta$ is an infinitesimal surface-unit and the integration gives the area of the entire triangle. From the expression using the three constant *k* values we get these:

$$k=1 \quad \alpha + \beta + \gamma - \pi = \Delta$$
$$k=0 \quad \alpha + \beta + \gamma = \pi$$
$$k=-1 \quad \pi - (\alpha + \beta + \gamma) = \Delta$$

This means that the area of a triangle is proportional to the sum of its internal angles. So, this emerges that in spherical case *>180°*, while in the hyperbolic case, *<180°*, and we get back the Euclidean case if *=180°.*

A further result is that this area calculation can be applied also in general case - in an infinitesimal sense - even when the *k* changes point by point.

CONCLUSION

Gauss's work is not the composition of the non-Euclidean geometry; however, these results undoubtedly deserve the *remarkable or prominent theory* name. Consequently, Gauss's name suitable beside the names of Bólyai and Lobachevski.

In addition, the consequences of this theorem led us to Riemann Geometry.

For the physicians means that if any physical space or motion describable with Gaussian coordinates may calculate according to non-Euclidean geometry and vice-versa.

This has special significance for me because I am not a fan of scientific racing or star making. I rather much believe in the more effective work, make it by one or plenty, anyone. This statement is extremely important these days when science has also promoted collaboration. Please remember to all participants and not let just the leaders win the glory and have the recognition. I know it's not easy, though only this is worthy.

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[4] Gauss: Disquisitiones generales circa superficies curves. 1827. Commentat. Soc. Göttingensis, VI. (Edition in the English language: Dover Publications. ISBN 0-486-44645-X.

[5] Metric space. https://en.wikipedia.org/wiki/Metric_space.

[6] Weisstein, Eric W. "Gauss's Theorema Egregium." A Wolfram Web Resource. http://mathworld.wolfram.com/GausssTheoremaEgregium.html

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Thoughts Concerning Artificial Intelligence & Machine Learning Part I

Peter G. Gyarmati

Abstract:
This study, Thoughts Concerning Artificial Intelligence & Machine Learning Part I is about Artificial intelligence and machine learning that are nowadays one of the daily tasks of digital technology developers. Almost every day, we hear more and more miracles performed by robots, and about computer programs that solve previously impossible-looking problems. Is there a theoretical foundation at all, do we know whether machines can think? The question is exciting and still open. The study introduces the Readers to the arguments and debates on this issue.

Keywords: Artificial intelligence, machine learning, mathematics, informatics

INTRODUCTION: PURPOSEFULNESS

'They say, do the impossible!' 'If you tell me what's impossible, I'll do it.' (Peter Gyarmati)

We are living in an era of all-encompassing importance and development of machine learning, artificial intelligence (AI). There is a huge competition in economic life for the market share of assets made from the AI results, perfectly justifying John Neumann's[1] former statement that "there is no cure for development". To understand this huge interest now, it is worth looking back at the not-too-distant past that laid the foundation for our knowledge today.

Can machines think the question has arisen as computers and their peers engage in activities that a person performs with their brains? "A machine can process information, calculate, infer, and answer: perform rational operations on information. So, the machine can think[2]."

The question, or the statement, provoked a highly heated, in many cases extreme, overheated, passionate debate at the time. This is understandable, as the issue also touches on deep-rooted emotional and religious beliefs. The other extreme position vis-à-vis Berkeley is represented by the Church: the machine in principle, cannot think because thinking is a property of the soul that is of divine origin. Again, others have argued that machines are incapable of thinking because thinking is essentially tied to living matter, like the brain, but machines are made of dead matter. The issue has also prompted professionals to conduct in-depth investigations. In the course of these, it soon became clear that to answer the question, it was first necessary to examine, not only in general but also specifically, what the concept of 'thinking' actually means. Already in the motto, there was a lack of exactness, which always stems from some conceptual area.

ANSWER?

Different answers can be given to the question raised, depending based on what society, from what point of view, and even what kind of basic-skilled professional is trying to formulate the answer. Physiologists provided they dealt with the issue at all, came to a somewhat reluctant,

[1] "There is no cure for development" J. von Neumann: Collected works. Pergamon-Press 1963.
[2] E.C.Berkeley: Giant brains or Machines that think. Wiley; First Edition (1949).

cautious stance. Stanley Cobb[3], an English physiologist, writes, "The brain is an organ of consciousness. In man, the incredible complexity of the brain is what makes thinking possible, but any in-depth study of the anatomy and physiology of the brain cannot explain consciousness on its own. Thinking is a series of events that depend on the interaction of information generated in some parts of the brain by external stimuli and from other brain parts. ' This definition is interesting because it perceives thinking as a realistic - that is, material - sequence of events that occur in response to stimuli from the outside world. On the other hand, it is inherently resignable because of the complexity of the logical structure of the brain.

As early as 1936, the English mathematician A.M. Turing[4] showed that any number (for example, the solution of a mathematical problem) for which a so-called *effective method* (finite number of rules; algorithm nowadays) can be given can be calculated using a (then even hypothetical) automaton. Such an automaton has since been called the Turing machine.

Concerning the computer[5], W. S. McCulloch (physiologist) and W. Pitts (mathematician)[6] formulated the same theorem in such a way that any procedure - expressed fully and unambiguously in words - can be accomplished with a suitable combination of a finite number of universal switching elements. Such is the case with living neurons, they claim.

From this, however, John von Neumann drew the important conclusion that, within the current technical limitations, computers can be programmed to perform all operations that can be included in clear rules. Everything that can be expressed verbally or with verbal questions can also be realized!

A. M. Turing, putting aside all emotional and religious motives, based on an inventory of all the relevant circumstances, came to the following conclusion: a machine can be said to 'think' if, under clearly defined experimental conditions, any human question can be answered in such a way that the questioner concludes that the answer is of human origin. According to this, the definition of thinking is operative, that is, equivalent to the behavior observed from outside.
The correct question, then, is not whether machines can think, but rather, what transactions can be programmed on the machine. To what extent can a have given machine think? By 1962, we had already solved logical problems with computers and proved mathematical theorems[7]. They thought that by the end of the century, we would be free to talk about machine thinking without provoking any contradiction, despite the large number of counter-opinions.

OBJECTIONS

You may want to review these and consider them below:

Theological Objection

Thinking is a function of the human soul, given by God, but not given to any other animal or machine.

[3] S. Cobb physiologist, England.
[4] A. Turing: The computer and the brain. MIND, 1950.
[5] P.G.Gyarmati: A contribution to the Hungarian computer history, 1958-1968.
[6] W. S. McCulloch, W. Pitts, "A logical calculus of the ideas immanent in neurons activity", Bull. Math. Biophysics, vol. 5, pp. 115-133, 1943.
[7] Computer and Automation, 1962. 9.

A counter-argument, on the other hand, is that according to the Old Testament, certain animals also have souls. The soul only needs to have a proper brain, which is just a matter of mutation. Then there is the fact that, according to the Mohammedan view, women have no soul. Finally, theological arguments can only live on until sufficient scientific knowledge is available to us.

Ostrich Policy
The consequences of thinking machines are unpredictable hopefully this will not happen. The reason is the feeling of human superiority or the fear of losing it.

The reality is that business relationships do not care about anything with any fears or consequences, the development cannot be stopped.

Mathematical Objection
There are limitations to the performance of discrete-state machines. According to the Gödel theorem[8], any sufficiently powerful logic system can make statements that cannot be refuted or proved within the system, unless the system itself contains a contradiction. The consequence is that the logic machine's response will be incorrect or non-responsive at all.

A counterargument although the human element is always able to respond, it is how many of them are at fault? Some people are smarter than a particular machine, but obviously, there may be machines that are smarter than he is, and so on.

Self-Awareness
As long as a machine cannot write a sonnet or a concert based on perceived thoughts, but purely by results of random arrangement of symbols, we cannot agree that a machine is equivalent to a brain that not only writes but also knows that it has written. No mechanism can take pleasure in its success (artificial indication would be a cheap idea).

There are different levels of limitations, just as there are for humans. If A thinks, "A thinks and B doesn't," and if B thinks, "B thinks and A doesn't," and they argue about it, then we can only assume that everyone thinks — otherwise there could be no debate. It is not about someone or something performing a text parrot-like.

Lack of Skills
You may do a machine that does all of the given things, but you never know that it could do any X things. Here, under X, many qualities could be mentioned, for example, the machine should be kind, helpful, beautiful, friendly, have a sense of humor, love creamy strawberries, awaken love, etc.

Indeed, most of our machines are ugly, just right for the purpose, unable to react to changes in purpose, etc... Miniaturization, nanotechnology, and the discovery of new materials have made it possible to develop high-capacity and fast devices that are already quite independent of appearance, even they could be nice. They have enough memory, able to remember, learn, and even have significantly greater capacity and speed than the human brain; what's more, they work

[8] Gödel, Autriche mathematician. The philosophy of mathematics entering the 21. Century. Collected works 2013. p.61.

accurately and reliably. We can see that there are no boundaries, only the results achieved are incomplete. There are many possibilities and still plenty to do.

Right to Make a Mistake

Machines, by their very nature, are infallible. If that were not the case, we would not be using them. Of course, this is not about the malfunction.

Why is this wrong? Theoretically, these are variants of solutions with different values. Such as correct, less correct, satisfactory, in some sense bad, or incorrect. Starting with the ability of machine learning, we can conclude that the machine may also come to different conclusions, just as men may make mistakes because the things learned come from a different environment than their application.

Lady Lovelace[9] Brought Up

Machines cannot initiate, and cannot create new things.

The objection was, first, that the statement could only relate to the observed assets at its disposal. Secondly, the question is; can a machine cause a surprise, that is, do something we did not expect? It can! For example, when it turns out that some of my assumptions, my calculations were incorrect because the machine came up with a different result or already knows and reports from its database that the theater ticket has run out but can get one for the next performance. This is based on an always up-to-date database - from there everyone buys tickets. So, the machine knows what we do not, the machine can speak if there will be a performance that interests us.

The Contradiction of The Continuous and Discrete

Man is constantly affected by and responds to environmental influences. By the discrete way, there will be drops in response.

Discoveries in neurology since its inception have demonstrated the discrete functioning of the brain. Where necessary, the nerves can maintain their signal continuously. The machines are also perfectly suited for this: the control and the regulation are discreet, and the intervention is continuous. Almost every cybernetic system is built in this way.

Unbinding of Behavior

Is it possible to create a set of rules that would describe to man, to society, what to do in any case, how to behave? If that were the case, man would be a machine, though man cannot be a machine! The counter-argument is that nature, the laws of nature, regulate us completely since we are part of it, yet we do not consider ourselves machines. We know, however, that our politicians, ordering lawyers and others, working hard to "formulate" all sorts of rules as fully as possible. An everyday term is "zero tolerance". Fortunately, this has not been the case so far, and they think power is the right method, for which they have many miracle machines: military tools and methods.

Perception Beyond the Senses

The phenomena of telepathy thought reading, foresight, and the transmission of the will disturb even our scientific perception, so we do not want to make a machine for such a purpose.

[9] Lady Lovelace: first machine programmer. Worked on the Babbage analytical machine.

Another application of perception is the creation of networks. On a very wide scale, we can get answers to our questions today that are beyond the capacity of our senses. Only the bugaboos and ghosts are missing from there, maybe the next generation still will be able to produce and display them on the World Wide Web.

Natural Way

It took nature a few million years to create human intelligence. How long does it take a man to complete artificial intelligence up to the level of human intelligence, given the accelerated scientific and technical progress and achievements? Will he be able to do this at all?

Nature has solved this task with diversity, mutation, and significant environmental changes. Living creatures reproduce themself, respond to their environment, and have an energy cycle. Imitation of the living requires at least the artificial realization of these factors.

Individuals learn from their relationship with the environment and each other, and certain parts of it are inherited during reproduction, as well as further developed and changed through mutation. What is "conscious" —intentional — from these we call development. The other changes are random and create diversity. This definition may not be accurate about understand tribal development. Nevertheless, we know that the environmental experience and mutation build on each other creates it, and besides the human brain is a glaring case. To the best of our knowledge today, this is our ability given by nature, which is created through knowledge, intelligence, inheritance, experience, and learning. Therefore, intelligence is a process that develops in every human being throughout his/her life!

THE CREATIVE MEN

However, there is a small flaw in this reasoning, namely the part of intelligence that is "built into" the brain during inheritance. This is partly explained by the further inheritance of knowledge acquired by ancestors, but the first such inheritance, or ability, is already debatable. Is it God, some creative origin, a game of nature, or a coincidence? Man created Frankenstein[10] and other companions, but they always felt the need additionally a "life-giving spark," without which a soulless, dead thing would remain. Modern literature also goes so far as to make any artificial intelligence feasible, but that, without man, remains completely meaningless.

SOME DANGER AND MORE QUESTIONS

Rather, they indicate the danger of a high degree of artificial intelligence, when machines become dominant and turn against man. This is an obvious assumption, as people are also constantly turning against each other. Such duality exists in our world for ages, on the one hand, we create devices with certain intelligence, and on the other hand - we entrust them with laws, rules, and regulations, that is, we subordinate ourselves to the "sovereignty" of these devices. For example, when the car's engine is running, the onboard control computer closes the doors for some thoughtful protection. It will not open that on any request, it will only act following the provisions of its program. An even more serious example is the widespread view that we need to learn fewer and fewer things because, if necessary, the "machine knows" it and is always at our disposal. This can be appropriate as long as the machine is the doer and does it safely and always correctly. However, is it really can it be every time? Because if not, who will notice and change it? Another machine? After all, "knowledge" is in the machine!

[10] Mary Shelley: Frankenstein, the modern Prometheus. Cosmos Fantastic Books.

Despite the objections, we can state that machines are capable of thinking and suitable for things and behaviors that have been attributed only to man up until now. We also know that this is not one piece of a complete machine, also the man is not just one, but a whole society. We have also learned that just as a man is not infallible, so is not the machine, unless it is our express intention, as we expect from automatic machines. The machine also always learns and applies the experiments in a given environment.

This statement raises new questions! Is thinking the result of the intricate interplay of many kinds of algorithms? On the other hand, is there a certain "qualitative leap" that separates, as it does, between the living creatures and the lifeless, according to the best of our knowledge?

The answer to these questions is open, but this should not hinder the overriding intention of the human world to develop. In this, case the ever-increasing development of machine learning, artificial intelligence, robotics, anthropomorphic devices, etc.

We are constantly looking for the answer and we have some solutions. In a study, John Neumann writes,[11] "The human intellect has many qualities that cannot be approached automatically. This type of logic, commonly referred to as "intuitive," is something that we do not even have a normal description. The best and most we can do is to divide all the processes into ones that are machines and ones that people can do, and then we figure out ways to connect the two". Even today, we think this is the way of development: we have a goal, we have a task, and the final solution may not be possible, but not necessary.

THE BIRTH OF AI

The birth of the idea of the thinking machine immediately gave hope to the mechanization dream of intelligence. The first artificial intelligence congress[12] held in Dartmouth[13] in 1956 and the first version of the LISP[14] completed as early as 1958. Hope soon dissipated, it turned out that any description of human reasoning becomes mere logic, and even at the moment it begins to operate on a machine, it becomes an algorithm, so no intelligence anymore. The algorithm is not intelligence, but a state sequence or rekurzor, as can be read extensively in the computer science literature. A typical example is the perceptron[15], which is merely an approximation of the neuron to an artificial model, far from a proven definition. However, there is no reason to despair, as the result - the perceptron model and its variants - is a well-applied tool in many areas: recognition and search algorithms, and so on.

Character-, speech-, language-, and image recognition were the tasks of the beginnings, which with more or fewer pitfalls, still seem to be a task today. There have also been many achievements in artificial intelligence technology, primarily in the field of cognitive sciences, through expert systems, and statistical theories ranging from robotics, data mining, and automation issues, to human-machine relationships, and talking/speech recognition miracles.

[11] The effects of the newest scientific results to the Economics. 1956. Looking Ahead, No.4. p.11.

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[13] http://www.formal.stanford.edu/jmc/history/dartmouth/dartmouth.html. Retrieved 30. August 2007.

[14] Declarative programing languages: LISP, ERLANG, PROLOG, SQL, in certain way also the HTML and companies. These are according to the logic of AI. (The other types are the imperative - command given like - languages, which are the nature of the computer.

[15] P.G.Gyarmati: Some words about networks, ch.17. Perceptron pp.117-122. TCC COMPUTER STUDIO, 2011.

SUMMARY

The question of machine thinking is not dormant; at most, it appears in other, newer forms: perhaps there is not only one path – a humanlike way – that leads to intelligence, say the latest thoughts.

I am confident that the field of artificial intelligence is always renewed[16], able to meet new challenges and translate useful results into useful things. At the same time, keep in mind the dangers that humans can incorporate into their machines, or intervene intentionally or unintentionally, most of the time based on some interest and without any human responsibility. Besides the scientists nowadays, the technicians - the programmer, the builder, and the applier of artificial intelligence - also have a huge responsibility.

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Well Water Disinfection in Wukari Using Solar Energy

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Abstract:
The disinfection of water using solar energy (SODIS) is a simple and inexpensive purification technique. The system has feast through the emerging world and is in everyday usage across over 50 nations both in Asia, Latin America, and Africa. Over an estimated 5 million people sterilise their intake water using solar disinfection (SODIS) method. Well water disinfection using solar energy (radiation) in Wukari town, the technique consists of placing water into transparent plastic or glass containers (normally 1 L PET beverage bottles) which are then exposed to the sun. Exposure times vary from 10am to 6pm depending on the intensity of sunlight and sensitivity of the pathogens. Its bactericidal outcome is built on the mutual effect of warm air heating of solar sunlit and UV radiation. It has been repeatedly shown to be effective for eliminating microbial pathogens and reduce diarrheal morbidity including cholera. Beginning from 1980 to date, report has shown that, much research has been conducted to explore the mechanisms of solar radiation induced cell death in water and conceivable improvement techniques of making it faster and safer. This report was on practical attempts to revise all relevant knowledge about solar disinfection from microbiological issues, laboratory research, solar testing and including real application studies, limitations, as well as examining the factors influencing adoption of the technique and health impact.

Keyword: Disinfection, Escherichia coli, Solar radiation, Staphylococcus aureus, Ultraviolet ray

INTRODUCTION

In our world, water is very important in carryout most of our human activities, "Water purification is the process of removing contaminants" from a water source so to be used for drinking, washing and industrial purposes. Purification occurs to limit the levels of certain components of the water so to reduce the potential associated health risks. The world health organization has identified 752 substances that may be present in well water" [1], and it is many of these elements that purification aims to remove. From "minerals, fungi to parasites, viruses and organic matter" the levels of these elements need to be reduced to minimal quantities for water to be classified drinkable. Water purification techniques have evolved with advancing technology over the past decades, from "simple systems based on the imitation and adaptation of naturally occurring processes" such as sand filters, to the complex methods.

The technique of solar water disinfection (SODIS) is thought to date back to 4000 BC, SODIS was first studied in-depth in 1979 by Aftime Acra, a researcher and Professor in the Department of Environmental science at American university in Beirut. He, with his assistant, Yester Karahagopain, developed a disinfection method that was easy to use and relatively inexpensive. Acra claimed that pathogenic microorganisms present in water could be very easily destroyed with solar radiation, especially ultraviolet radiation [2]. In 1991, the Swiss Federal Institute of Environmental Science and technology and various departments of water and sanitation in

developing countries confirmed that SODIS helps inactivate bacteria, parasites, and viruses in water. SODIS has been used extensively in developing countries since that time.

The World Health Organization (WHO) approximations had it that, about 780 million individuals globally don't have access to clean water [3]. Having access to a clean water supply is essentially, not only to prevent fatal dehydration but also for sanitation purposes, as more than 3.4 million people die each year from water sanitation and hygiene related causes [1]. The WHO also states that there is a clear connection between improved water treatment and economic growth, followed by an overall development of the area. According to their report, [4], making water a part of economic development, poor countries with improved access to clean water and sanitation services had an annual average economic growth of 3.7%. This is far higher than the average annual growth of 0.1% for similarly poor countries without the improved water quality. This is due partly to the fact that improved water treatment means less incidents of water related illnesses, which in turn strengthens the country's work force and boosts productivity, while decreasing the health care burden. It also has a positive effect on education since fewer children miss school because of regular illness. This improves the country's overall education which increases the skilled labour force and further enhances the economic growth and development of the country. The WHO report 1 also states that "Actins that target poor people have the largest marginal effect." meaning there is an enormous importance in improving water treatment in any developing country. Especially in rural areas (which tend to be the poorest). A lot of progress has been made in recent years in improving the water standard in highly populated areas where there is access to a more developed infrastructure, with electrical grids and a larger demand for clean water. Less developed are water sanitation techniques for areas with lower population densities, where any method of water purification needs to be independent of electricity since there is most likely no access to electrical grids. To provide cleaner domestic water to rural populations in third world countries new cheap and cost-effective methods for water sanitation is of vital importance. When implementing any kind of water sanitation in an area, consideration must be taken regarding potential lack of special skills and knowledge about water sanitation, since these areas largely coincide with areas of illiteracy and very limited education. Consideration also must be made regarding the previous stated lack of electricity. This means that any purification process chosen needs to be easy to maintain, work independently from electrical sources, and be housed in a facility with both low investment and maintenance costs, to make it affordable for more people. The economic aspect is very important, not only for the resident population but also to get people elsewhere to see it as a viable method of water sanitation and motivate different types of benefactors such as relief organizations to help finance the construction of water purification facilities in rural areas.

Significance of the Study

The project was targeted at sensitization and orientation of the people of Wukari local Government Area and the public, especially the students and researchers within and without Federal University Wukari, to understand the importance of well water disinfection using solar energy and to prevent the people of Wukari from drinking contaminated water.

Solar Water Disinfection Concepts

According to Wegelin [5], solar water disinfection is a treatment process in which water is exposed to sunlight over time. Solar water disinfection is an environmentally friendly and low-cost method to disinfect water. The solar water disinfection on which this work focuses is known as SODIS.SODIS involves placing water to be treated in a clear, plastic bottle and exposing it to the

sunlight for a sufficient time to inactivate pathogenic microbes [6]. According to Parsons [7], solar water disinfection occurs via three mechanisms which, individually or collectively, may kill or otherwise inactivate pathogenic Microorganisms:

1. DNA alteration by ultraviolet light
2. Production of reactive photo-oxidation species
3. Thermal inactivation

The process of solar water disinfection is generally effective between 35°N and 35°S. For areas outside of this region, SODIS does not tend to be very effective because of limited solar radiation and a colder climate [7]. Solar water disinfection is widely used in about 31 countries by more than two million people for water disinfection [8].The World Health Organization 2002 [9] states that SODIS in general is a cost effective and environmental sustainable process which employs solar radiation in the spectrum of UV-A light (wavelength 320-400nm)and heat (which causes an increase in water temperature) to destroy the pathogenic microorganisms present in biologically contaminated water contained in the bottle. According to Kenya Water for Health Organization 2009, [10], guidelines for drinking water, SODIS is a viable alternative method for disinfection of water in small quantities at a household level in which only solar energy is involved. The SODIS process is quite simple. Generally, clean 1L polyethylene terephalate (PET) bottles are used. Low-turbidity water (<30NTU) is poured to fill the plastic bottles, and the bottles are then shaken to increase the dissolved oxygen content. The bottles are then exposed to sunlight for an extended period. In full sunlight, this period is 6-8 hours. If the temperature of water inside the bottle reaches 45-50 degrees Celsius, then disinfection is about three times more effective. If the weather is cloudy, then the bottles are exposed to sunlight for 48 hr or more to achieve below-detectable levels of bacteria. If the temperature of the water inside a 2L PET bottle in less than 20°C, then UV radiation is the only responsible agent for water disinfection [5], and the process of disinfection may take considerably longer. According to Shanahan, [11], the solar water disinfection threshold for microbial disinfection of drinking water generally involves solar exposure to 3-5 hours of solar radiation above 500W/m^2. Strong synergistic occurs if the temperature of the water is above45°C. The increase in temperature of water exposed to sunlight is caused due to absorption of red and infrared light creating heat. If the temperature in the water rises to 55°C, then the thermal process by itself is responsible for the inactivation process.

TURBIDITY

The efficiency of SODIS is very much inversely dependent on the turbidity of water. Turbidity is a measure of the cloudiness of water. Cloudiness in water is generally due to presence of clay, silt, finely divided organic and inorganic matter, and it is measured as turbidity [12]. According to SANDEC report [13], turbidity of the water to be treated by solar water disinfection should be less than 30 NTU, where NTU is the acronym for nephelometric turbidity units, a measure inversely related to optical clarity. Solid particles in water that is to be treated via SODIS tend to decrease optical clarity and tend to block the passage of ultraviolet radiation through water, thereby decreasing the efficiency of the SODIS process. If the turbidity of water to be treated via SODIS is more than 30NTU, the water should be pre-treated before it is use, using sedimentation or straining [12].

ULTRAVIOLET RADIATION

In SODIS, radiation in both the infrared and ultraviolet ranges is used to disinfect water. As shown in Figure 1. both infrared and UV radiation lie in portions of the electromagnetic spectrum of light.

Heat is produced due to absorption of light in the infrared spectrum, and ultraviolet radiation tends to inactivate pathogenic microorganisms.

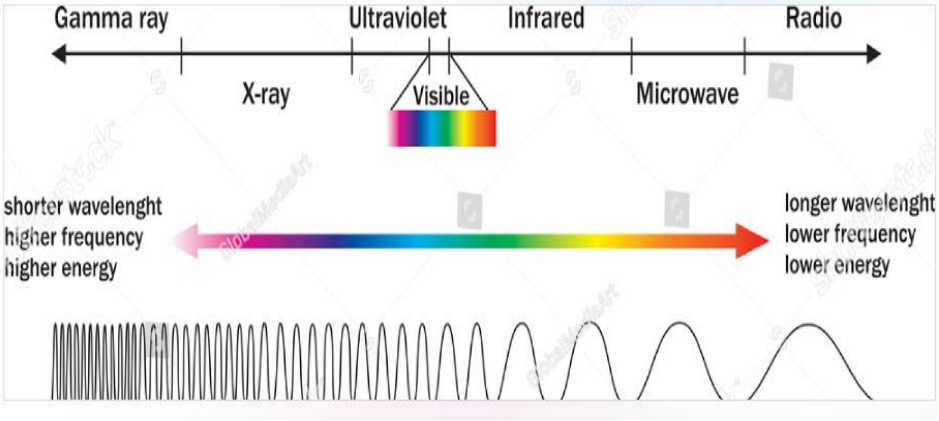

Figure 1. the infrared and UV portions of the electromagnetic spectrum. (Adopted: https://www.shutterstock.com/image-vector/visible-light-diagram-color-electromagnetic-spectrum-)

Table 1. shows the optical radiation spectrum.

Region	Wavelength range
UV	100 – 400 nm
UVC	100 – 280 nm
UVB	280 – 315 nm
UVA	315 – 400 nm
Visible	400 – 780 nm
Infrared (IR)	780nm – 1 mm
IRA	780 nm – 1.4 μm
IRB	1.4 μm – 3.0 μm
IRC	3.0 μm - 1 mm

Ultraviolet radiation is divided in to three different types as shown in table 2.1 of radiation. depending on the wavelength. There are three basic types.

1. Ultraviolet A-Rays
2. Ultraviolet B-Rays
3. Ultraviolet C-Rays.

Type 1 UV-A

Wavelength:320-400nm.This type of radiation is not absorbed by the earth's ozone layer. UV-A radiation damages DNA of living cells which helps in inactivating the cells. Highly reactive oxygen species are produced due to absorption of UV-A through photo sensitizers that cause base changes and strand damage of the microorganisms [14].

Type 2 UV-B

Wavelength:290-320nm.This type of radiation is not completely absorbed by the ozone layer. Only 1% of this radiation reaches earth surface.

Type 3 UV-C

Wavelength:100-290.This type of radiation is totally absorbed by the atmosphere layer.

Effect of Ultraviolet (UV) To Microorganism Cells

The basic mechanism of microbial UV inactivation is the dualism of photo thermal and photochemical effects. The photo thermal impact is because of surface heating by absorbed UV energy. Evidence was if UV radiation causes cellular rupture by overheating if fluencies exceed 0.5 J/cm2; however, other studies suspected photo thermal effects to be of minor importance as inactivation of microbial cells with UV light was also successful at low surface temperature. Explicit photochemical impacts originate from the captivation of UV light by pyrimidine and purine bases in nucleic acids and nucleoproteins. Light sources enable direct DNA damage by stimulating single strand breaks and formation of covalently linked thymine dimers, which inhibit correct transcription and replication. However, pulsated light is suspected to cause extend membrane damage and elution of cellular contents, presumably because of its higher peak power. Indirect effects arise from UV induced photochemical generation of peroxyl or hydroperoxyl radicals that are highly reactive oxidizers and attack ligand membranes, proteins, enzymes, and DNA. This effect can be enhanced by additives that liberate reactive species upon UV radiation; in that case, the object to be decontaminated is coated with a solution containing the photosensitizer (e.g., H_2O_2). As regards susceptibility toward UV, gram-negative bacteria are most sensitive, followed by gram-positive, fungi, and bacterial spores. Pigmentation is also probably protective because of partial UV absorption.

Infrared (IR):

It is a type of electromagnetic radiation with longer wavelengths than those of visible light, and is therefore generally invisible to the human eye, it is including wavelengths between 780 nm and 1000 μm. IR is divided into different bands: Near-Infrared (NIR,0.78-3.0 μm), Mid-Infrared (MIR,3.0-50.0μm) and Far-Infrared (FIR,50.0-1000.0 μm) as defined in standard ISO 20473:2007 Optics and photonics-Spectral bands.

Solar Radiation and Cellular Damage:

The solar irradiance incident on the outer Earth atmosphere is approximately 1360 W m-2-this value varies with position within the elliptical sidereal orbit of the Earth as it orbits the Sun. Water vapor,CO2,ozone and oxygen, in addition to pollutants in the atmosphere, scatter and absorb various portions of this such that for a typical cloudless atmosphere in summer at the equator, the received irradiance on a horizontal surface at ground level on the equator is reduced to roughly 1120 W m-2.Thus we have 1.12 kJ m-2 of optical energy available in each second to inactivate whatever microbial pathogens are present in water exposed to sun-light.

Solar Reactors for Water Disinfection:

While plastic bottles are cost-effective reactors, one of the main drawbacks is the limit they place on the unit volume treated water, usually less than 2 L per batch. If greater batch reactors or containers are required, then the ability of the reactor wall to transmit sunlight is one of the most important criteria. In this regard, non-coloured glass is preferred. Extensive work by Acra et al. showed that ordinary glass bottles and glass jars could transmit up to 90% of solar radiation particularly in wavelengths in the UV-A region. Borosilicate glass tubes could be a good solution for flow solar reactors since they transmit up to 90% of the available UV-A as well as 45% in the more germicidal UV-B range, making glass a more suitable option [15].

Aluminium Foil:

The SODIS bottles are usually only illuminated on the upper side of the reactor that faces the sun. There have been several attempts to concentrate solar radiation using Aluminium foil with the

aim of increasing the radiation inside the bottles. Aluminium foil conferred to the back of the bottles increased disinfection rate constants by a factor of 2. Rijal and Fujioka used also solar reflectors and observed improved efficiencies which they attributed solely to the increase in water temperature of the system. Reflective solar boxes can reduce disinfection time to 3-4 hours.

Trapping Solar Energy:

The methods from Dhaka University are constructed in a way that captures solar insulation. The solar insulations have the form of electromagnetic waves with a large range of wavelength that includes all spectrums from ultraviolet, visible, short infrared and long infrared radiation [16]. When they reach earth some of the radiations filter though the atmospheric layer of gases. Some of the radiation gets absorbed on earth and their energy contributes to heat up the temperature that makes this earth habitable for animals and plants to live [17]. These warm objects then radiate long infrared radiation, some of which passes through the atmospheric gas layers back to space again, otherwise the temperature would be unbearable to live on earth.

Ability to Heat Up a Thick Water Layer:

The water can utilize both trapped solar energy and UV-light simultaneously, which is a big advantage. This deign usually have a surface glass which trap the radiation (heat) inside the constructed solar disinfectant box, this is mainly to block heat inside the disinfectant due short solar wave, aluminium foil This is mainly to reflect the solar rays to fall on the water inside the constructed disinfectant. Under the constructed disinfectant box is painted black colour which absorbs heat which help rise the water temperature. The black surface absorbs solar energy, heats up, and warms the lowest layer of water through conduction figure (2.2).

The whole water layer is then heated through convection. A transparent aluminium foil sheets are spread on top leaving air gaps in-between. Separating items, such as hay straws, could be used to prevent the plastic sheets from touching each other. The air gaps provide insulation to prevent heat loss towards the top. The transparent covers and water allow visible and short infrared solar radiation to reach the black surface below. The long infrared solar radiation is emitted by the heated water and gets trapped by the transparent aluminium foil sheet above, [18]. It needs to be mentioned that the aluminium foil can get affected after some time of use, therefore be aware to exchange then while turning gloomy so that the infrared radiation can reach the water. In this device UV-light also passes on to the water layer.

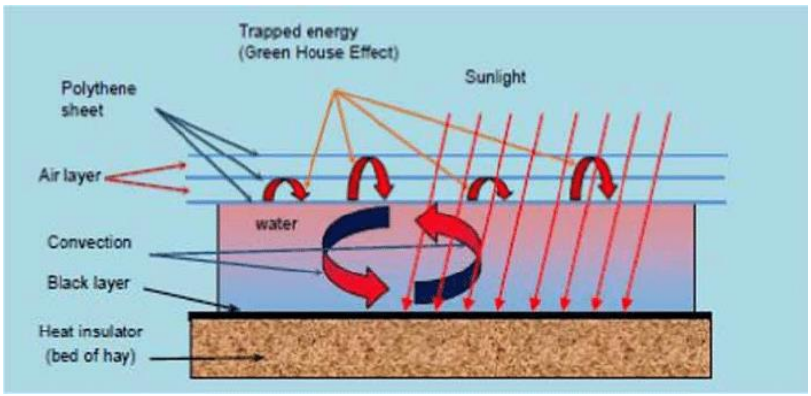

Figure 2; Schematic picture of solar water pasteurization and trapping of solar radiation. (Adopted; https://www.researchgate.net/figure/Schematic-of-solar-water-pasteurization-device-mechanism)

MATERIALS AND METHODS

Materials

The materials used for the analysis is the work, they include.

1. l litre of pet (polyethylene terephalate) bottles use for collection of water samples
2. Construction of crate box
3. Aluminium foils use for the collection of sun radiation
4. Wire loop use for picking organism or growth
5. Slide for creating smear
6. Plate or Patrice dish use for culturing
7. Gas cylinder for heat fixing
8. MacConkey 4.8g and Nutrient Agar
9. Water (100g)
10. Conical flask
11. Safranin, crystal violet gram's iodine
12. Incubator use for temperature
13. Microscopes
14. Autoclaves, Hot plates,
15. Thermometer
16. Colony counter
17. Scale balance
18. Hot plates,
19. Solar power meter (pyranometer)

Study Area and Sampling:

The study was conducted in Wukari, a town located in the Southern part of Taraba State, with latitude 7.85°N, longitude 9.78°E with altitude 152, Nigeria. It is one of the largest local Government areas of the State with three wards. Well water constitutes the major source of drinking, bathing, and other domestic purposes in this area. Most of the wells under study were privately owned and are usually open to public. Drawing of water from these wells is done using 5-10 litre containers tied to a long rope. The wells are not less than 4 years old. Samples were collected from the three areas (federal University Wukari campus area, wapanghaku, Takum junction area and best centre) and three stream samples (Mission quarters 1, Mission quarters 2, and Banana Island) of the local Government area between April and May 2023. Water samples from four wells and three samples of water from the streams mentioned above were randomly collected for analysis.

Sample Preparation:

Stage 1: Collection of Water Samples (Well and Stream):

Water samples were collected in sterile bottles from the various wells as shown in plate 3.1 following a method described by Ngwa and Chrysanthus (2013) with slight modification. The sterile bottles were tied with a strong string to a piece of metal of about 400 g. The bottles caps were aseptically removed, and the weighted bottle lowered into the well to a depth of about 1.5 meters. The bottle was brought up to a surface and covered with a screw cap ensuring no air bubbles inside and was transported to the central laboratory, Federal University Wukari for further analysis.

Figure 3. Images from the Local wells (site pictures)

Stage 2: Treatment and Test of Water Samples:

Treated Water and Method Use

The four-water sample collected from different places as mentioned above in stage 1 is placed in the constructed disinfectant box. As shown in plate 3.2, the constructed box is raped in the interior with aluminium foil is set out under the sun from 10am-6pm. The water samples set under the sun in the constructed box crate were collected in the syringe for every 2hours each for inoculation as mentioned at stage 1 to produce result. The pure cultures obtained were characterized using, colonial, microscopy, indole test, biochemical and sugar fermentation tests, this concluded that E coli stain pink or red rod shape.

Figure 4. Diagram of a constructed solar disinfectant and the samples of water.

Methods

Theory of the Experiment:

The Solar Radiation Equations are:

Solar Disinfection:

When inactivation is done under constant irradiation conditions:
Disinfection kinetics (also for disinfecting agents like chlorine, UV, etc)
Obeys to a first order kinetics, Chick Law.

$$\frac{dN}{dt} = \text{KN} \rightarrow Nt = Noe^{-kt} \quad \text{.....(1)}$$

Nt: concentration of viable microorganisms at time t.
K: constant of disinfection rate
This relationship under solar radiation changes to:

$$\frac{dN}{dt} = \text{KN} \rightarrow Nt = Noe^{-kt} \quad \text{.....(2)}$$
$$Q_{uv} = Q_{uv.n-1} = Q_{uv.n-1} + \Delta t_{n.} UV_{G.n.} A \quad \text{...(3)}$$

Experimental time is used to compare results when lamps are used.

When solar radiation drives the process, we can use the following evaluation parameters:

a) **Q_{uv}:** cumulative UV energy during exposure time per unit of volume of treated water (JI^{-1}).
b) **UV Dose:** UV energy received per unit surface during exposure time (J m-2).

$$Dose_{uv} = UV_{G.n}.\Delta t_n \quad \text{.....(4)}$$

c) **UV Energy**: total UV energy received during exposure time (J).

$$\text{Energy}_{\text{uv}} = \text{UV}_{\text{G.n}}.\text{A}\cdot\Delta\text{t}_{\text{n}} \quad \text{.....(5)}$$

d) Equation for determining the distance and amount of time needed to purify water.

$$l_{(r)} = \frac{pl}{2\pi r} e^{-aer} \quad \text{.....(6)}$$

$l_{(r)}$ = is uv intensity at a distance (mw/cm2)
pl = is uv power emitted per arc length of the sun(mw/cm)
r = is the radical distance from the sun (cm)
ae = base absorption coefficient of the water(1/cm)

Isolation of Escherichia coli (E coli):

Preparation of medial, (MacConkey and Nutrient Agar) MacConkey which is media through which organism are first grown while nutrient agar is a differential media where organisms are sub-cultured. In preparing macconkey,4.8g of MacConkey was weigh and diluted with 100m of silly-water in conical flask, the medial was sterilized in an autoclave for 120C at 15psi for 15 minute allows to cool to a temperature bearable to skin about 15-20m was poured to Petri dish allow to set on a bench, the sample was inoculated and incubated at 37C for 24 hours. After 24 hours the growth was observed and sub-cultured in nutrient Agar after 24 hours the growth was subjected to ground state reaction for configuration.

1. using a sterile inoculating loop, add 1 drop of sterile water to the slide. Prepare a mixed smear of Escherichia coli (G-rod) and Staphylococcus epidermidis (G+ coccus).
2. 2.Air dry and Heat fix.
3. Cover the smear with Crystal Violet (primary stain) for 1 min.
4. Gently wash off the slide with water.
5. Add Gram's Iodine (mordant) for 1 min.
6. Wash with water.
7. Decolorize with 95% ethanol. This is the "tricky" step. Stop decolorizing with alcohol as soon as the purple colour has stopped leaching off the slide (time will vary depending on thickness of smear). Immediately wash with water.
8. Cover the smear with Safranin for 30 seconds.
9. Wash both the top & the bottom of the slide with water.
10. Blot the slide with bibulous paper.
11. Using the 10X objective lens, focus first on the line and then on the smear. Focus the microscope or view the smear using the 100X (oil immersion lens).

Incubator: Laboratory incubators (Genlab) with model (MINI140) AND serial no. 12f076 also with a voltage capacity of 240AC 1PH 50HZ, Load 0.5KW 2AMPS. As shown in Plate 3.3, provide a controlled, contaminant-free environment for safe, reliable work with cell and tissue cultures by regulating conditions such as temperature, humidity, and CO_2. Microbiological incubators, these are used in the laboratory for growing and storing of bacterial cultures.

Autoclave: MODELYXQ-280S, vessel volume 0.018M3patedworking pressure 0.14~0.16Mpa power 2kw/220v 50HZ, As shown in plate 3.4, it is a strong heated container used for chemical reaction and other processes using high pressure and temperature. Autoclave (steam sterilizer), media preparatory and dispensing device for liquid media and microbiological culture media, it sterilizes at 120°C

Wire-loop: -is an instrument for picking growth in the media (MacConkey and nutrient Agar) or it is for transferring microorganism of growth media or for staining slide. The wire loop forms a small loop with diameter of about 5mm. It may be made of platinum or nichrome.

Microscope: -Microscope (GX ML1500) is an optical instrument comprising of an arrangement of lenses that expands the images of the object viewed through it. It is used for the morphological study of very small organisms which are not visible by naked eyes. This microscope is suitable for wide range of laboratories including biological research medical research etc, it combines high quality optics, professional grade stage movement and focusing technology with everything you would expect to find on scientific research grade microscopes costing many times more. The L1500 span signifies great value for money and is suitable for the viewing of almost all slide mount-up samples.

- Broad field oculars, choice of Achromatic or Plan Achromatic objectives.
- Coaxal rough/fine converge system, with tension and control stopper.
- Mechanical stage size:135mmX135mm.
- Height adjustable Abbe condenser, A=1.25.
- Illumination with 6V 20W halogen lamp, adjustable brightness
- Choice of monocular, binocular and trinocular heads

Scale balance: -Scale balance (OHAUS) model PA123 with a maximum capacity of 210g, readability 0.001g and has a power requirement of 8-14.5V-50/60HZ. It is used for establishing the weight or mass of a specimen; scientific balances are midst the more vital pieces of laboratory equipment.

Colony counter: -Model SC6 protected by Stuart-bio-Cote it has 1.7 x magnifiers with 50-100mm dishes the magnifier is available as an optional extra for counting very small colonies. As shown in Plate 3.6, it is a machine used in counting the number of organism growth on a media.

Pyranometer (solar power meter): -solar power meter is a device design to measure the solar radiation falling on a horizontal surface of the earth in watt per square meter (w/m^2). It is a digital solar power meter with a model LI-200R 634BTU/(ft2xh).

RESULTS AND DISCUSSION

Results

The results of the findings are as shown in tables below.

Table 2. Biochemical Test Result for samples of well water

SN	SAMPLE AREA	COLIFORM COUNT	GRAMS REACTION	IND RXN	CIT	OX1	GLU	LAC	SUC	H_2S	GAS	CAT	ORG
1	Campus Area	52	-	+	-	-	+	+	+	-	+	+	Ecoli
2	Wapangha ku	35	-	+	-	-	+	+	+	-	+	+	Ecoli
3	Best Centre	31	-	+	-	-	+	+	+	-	+	+	Ecoli
4	Takum Junction Area	29	-	+	-	-	+	+	+	-	+	+	Ecoli

Table 3. Biochemical Test Result for samples of stream water

SN	SAMPLE AREA	COLIFORM COUNT	GRAMS REACTION	IND RXN	CIT	OX1	GLU	LAC	SUC	H_2S	GAS	CAT	ORG
1	Mission Quarter 1	100	-	+	-	-	+	+	+	-	+	+	Ecoli
2	Mission Quarter 2	139	-	+	-	-	+	+	+	-	+	+	Ecoli
3	Banana Island	98	-	+	-	-	+	+	+	-	+	+	Ecoli

COLIFORM: Klebsiella, Proteus, E coli and Enterobacter aerogenes.

Table 4. Water samples and the isolated bacteria

Samples of both well and stream water	**Bacteria isolated**
Mission Quarter 1	*Staphylococcus aureus, Pseudomonas species, Escherichia coli*
Mission Quarter 2	*Klebsiella species, Salmonella species, Staphylococcus aureus, Escherichia coli*
Banana Island	*Staphylococcus aureus, Pseudomonas species, Escherichia coli, Klebsiella species*
Federal University Campus area	*Staphylococcus aureus, Pseudomonas species, Escherichia coli*
Wapanghaku	*Escherichia coli, Enterobacter species*
Best centre	*Enterococcus, Proteus species, Escherichia coli,*
Takum Junction area	*Escherichia coli, Pseudomonas species, Proteus species*

Escherichia coli Count (Cfu/Ml) for well water at different time Intervals.

Table 5. The reduction of *Escherichia coli* in the well water when exposed to solar radiation.

SN	SAMPLE AREAS	10am – 12pm	12pm – 2pm	2pm – 4pm	4pm – 6pm
1	University Campus area	18	10	7	3
2	Best Centre	5	5	3	0
3	Takum Junction area	22	4	3	0
4	Wapanghaku	27	24	9	6

Escherichia coli Count (Cfu/MI) for stream water at different Time Intervals

Table 6. The reduction of *Escherichia coli* in the stream water when exposed to solar radiation.

SN	SAMPLE AREA	10am – 12pm	12pm – 2pm	2pm – 4pm	4pm – 6pm
1	Mission Quarter 1	**4**	**3**	**1**	**0**
2	Mission Quarter 2	**21**	**5**	**3**	**2**
3	Banana Island	**10**	**6**	**0**	**0**

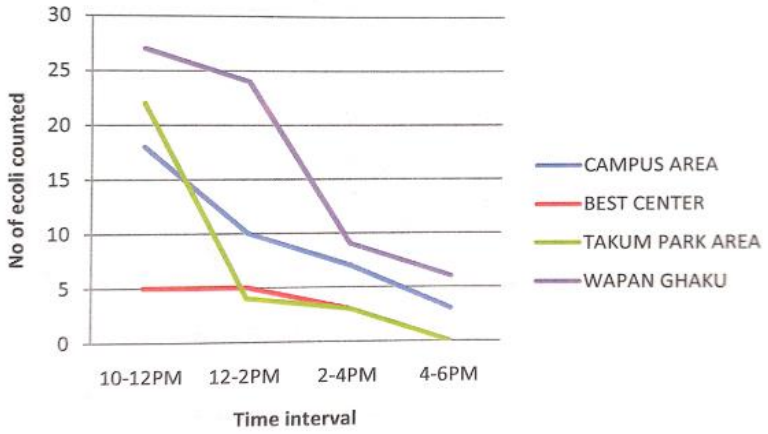

Figure 5. Disinfection of well water

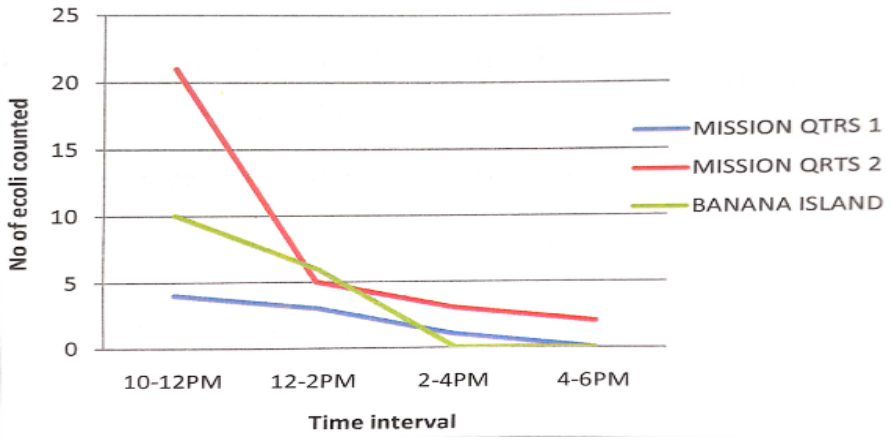

Figure 6. Disinfection of stream water

Table 7. The temperature and solar radiation during the sterilization of the water samples

SN	Time	Temp. (^{0}C) in	Temp. (^{0}C) out	Solar Radiation (w/m^2)
1	10am – 12pm	45	36	200
2	12pm – 2pm	54	44	400
3	2pm – 4pm	56	45	600
4	4pm – 6pm	39	34	800

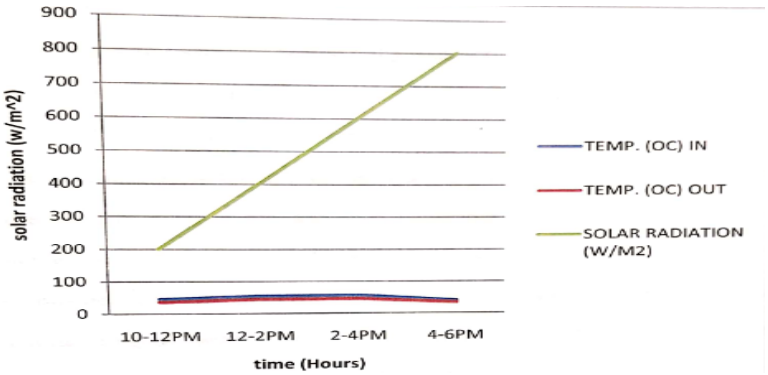

Figure 7. Solar radiation vs Time

DISCUSSION

Each of the water samples was serially exposed under extensive solar radiation(sun) after two hours each ranging from 10am to 6pm.Exactly1 ml of each of the 7 samples of well water and stream water samples was also taken in every hour and inoculated into a molten nutrient agar using pour plate technique. This was properly mixed and allowed to set, and then incubated at 37°C for 24 hours. The resulted colonies were counted, and result expressed as cfu/ml. In the table 1&2 above show the biochemical test used to identify gram positive bacteria and gram negative bacterial. In gram positive where the sign is (+) are in dole test, catalyse test, glucose test, gas, lactose, sulcate all the positive signs shows that there is E coli in the samples otherwise there is no E coli while gram negative (-) are: citrate agar, hydrogen(iv) oxide, oxides, and grams reaction. All the negative sign in various test mention shows the presence of E coli in samples otherwise no E coli present in the sample. The total viable count of bacteria in all the samples ranged from 12 cfu/ml (MQRTS) to 139 cfu/ml (MQRTS) for both well and stream water (Table 2 and 3).

Table 4 presented the bacteria isolated from various samples. The result showed that Escherichia coli was isolated from samples Mission quarters, Mission quarters, Banana Island, Federal University Campus Area, Wapanghaku, Best Centre, Takum Junction Area. Contamination of water sources have been reported by several authors as a medium of disease outbreak and spread in developing countries and rural areas [19] and [20]. In Wukari where the present study was carried out, treated pipe-borne water and public water supply is inexistent. Alternatively, the populace uses drilling water (boreholes) and wells (for individuals that cannot afford the cost of digging boreholes) for drinking and domestic purposes. In the present study, the total viable bacterial count which ranged from 12 cfu/ml to139 cfu/ml was high and less than the recommended limit of<500 cfu/ml. This observation is like the work of Ngwa and Chrysanthus [21] on well water sources in the Bambui student residential area, who reported viable count of bacteria in the range of 0.2-7.3x104 cfu/ml. The high bacteria count is an indication that the various water sources are high contaminated bacteria which could be of public health concern. The high values could be attributed to run-off water that enters some of the wells during raining seasons and particles from the environment which gain access into the wells from time to time. These values are high when compared with the permissible MPN index by world Health Organization of 10 coliforms/100ml of water sample. This observation is consistent with the reports of Krishnan et al. [22], Ngwa and Chrysanthus [21] and Gambo et al. [23] who reported high coliform counts in all well and borehole water analysed. The high number of total coliforms could be due to inadequate maintenance of the well water as many of the wells are uncovered. It can also be attributed to percolation of sewage into the ground water sources [23].

CONCLUSION

This project well water disinfection using solar energy is a project aimed to enhance the purification of water with the aid of solar radiation. Solar water disinfection, in short SODIS, is a type of portable water purification that uses solar energy to make biologically contaminated (e.g., bacteria, viruses, protozoa and worms) water safe to drink. Well water is the water drawn from a boring pit few meters below the earth surface using bucket, the world health organization (WHO) estimates that about a huge number of people worldwide lack access to clean water. Having access to clean water supply is essential not only to prevent fatal dehydration but also for sanitation purposes. Isolation of Escherichia coli (E coli) Preparation of medial (MacConkey and nutrient agar), Biochemical test used to identify gram positive bacteria and gram negative bacterial. In gram positive where the sign is (+) all the positive signs shows that there is E coli in the samples otherwise there is no E coli while gram negative (-) are: citrate agar, hydrogen (iv) oxide, oxides, and grams reaction. All the negative sign in various test mention shows the presence of E coli in samples otherwise no E coli present in the sample.

It may be concluded that the aim and objectives of the project have been met by successfully constructing a solar disinfectant and disinfecting well water. The data collected during the analysis demonstration area and monitoring at user level confirmed that SODIS is a reliable method for drinking water disinfection at household level. After years of research and field testing, the challenge of reducing the incidence of water-borne diseases through SODIS use is now lying in the hands of the institutions and field workers in charge of hygiene education and sanitation programs. Through appropriate diffusion of the information, intensive training of users and follow-up, people will have Access to a simple and affordable alternative to improve the microbiological quality of their drinking water at household level.

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Proactive Pipeline Corrosion Monitoring Using a Telemetry System in the Ukanafun-Calabar Pipeline Route, Nigeria

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Abstract:
Oil and gas pipeline systems in the crude oil refineries play a critical part in exploration, exportation and delivering of petroleum products and the energy resources required to power communities around the globe. The necessity to protects and secures these structures and prolong their valuable service life remain extreme economic importance since their disappointment will impact negatively on life, environment, and properties. The extra or additive cost for pipeline corrosion management represent a very small percentage of the original system constructional costs. The price of employing a corrosion control scheme has established to be of countless benefits in curtailing seepages and at the same time prolonging the service life of the pipelines. In this academic work, oil and gas pipelines was giving a pro-active attention by monitoring in situ and remotely for corrosion effects using the telemetry system with measured and calculated result.

Keywords: Cathodic protection, Corrosion control, Corrosion monitory, Pipeline corrosion, Telemetry

INTRODUCTION

The conveyance of oil and gas via pipelines at present, remains the most significant means of transporting these products across different terminals in the Niger Delta region of Nigeria, both for export and for local consumption. This conveying medium "the pipelines" are suppressed and buried in the corrosively hostile seaside soils. Though its can be reasonable to think that, with the intricate coating techniques that is place today, the menace of soil corrosion would have extinct. However, whether due to fault of manufacturer or that of Engineering design, materials deterioration after burying of these pipes underground is still a common challenge. According to the academic works of [1,2], they considered that the most economical means of prolonging the service life of oil pipelines is by combining a suitable coating technique with an application of cathodic current ran from an external anode. Cathodic protection (CP), [3] is a corrosion protection technique that is employed to abridged corrosion reduction of a metal surface by making that surface to function as a cathode of an electrochemical cell. This method, cathodic protection CP and corrosion control can be tenuously or remotely monitored using Pipeline Telemetry System (PTS). [4] recognized this system as a system that transmit data captured by instrumentation and measuring devices to a remote or an inconvenient station where it is processed and utilized. The used of the cathodic protective technique has been reported date back to 1824 by Sir Humphrey Davy [5], he had a successful cathodal protection against corrosion attached coupled to zinc, Edmund Davy also successfully protected the ironwork of buoys by attaching zinc block in 1829, also, cathodic protection was explored by the Canadian seagoing ships in 1950, [5]. The design or construction of a typical CP structure depends upon several

variables, such as quality of the pipeline coatings, the soil resistivity, the length of the pipeline to be protected, availability of power, these are variables that always call for independent investigation and analysis, [6]. The work of [7], suggested that CP can be achieved in two ways galvanically and electrolytically. In galvanic or sacrificial cathodic protection, the disintegrating objects made to serve as the cathode in the galvanic cell, while the anode, which is a metal of Mg, Zn protects a valued steel structure. The anode in this event is referred to as the sacrificial anode since it is the one been consumed through the course of protecting the steel structure. In considering Ukanafun-Calabar pipeline route, our area of study, record of the pipelines here are in remote settings with no access to national electricity supply line, even at the event of availability of the grid electricity, it is not suitable due to the instability and non-constant in supply. In this work, we decided to make do with a cheaper, steady, and reliable source of power, the solar power, to generate a direct current (DC) for the cathodic protection of the pipelines. This is because this energy can be obtained both in the rural and urban centers at a low cost and the arrangement will require little or no attention in putting it to operation aside the fears of local vandals. Also, the scheme has an added advantage of generating a steady DC power supply all year round.

ECONOMIC IMPACT OF CORROSION IN THE OIL AND GAS INDUSTRY

It has been observed by industry experts that, the total yearly cost of corrosion in the oil and gas industry can be express in monetary value to the tune of 1400 billion US Dollars. Giving the breakdown, shows $590 million dollars been expended in external pipeline and capacity costs, yearly expenses of $464 million in downhole pipes and another $322 million principal costs on other corrosion related cases [8] It is generally recognized in the industry that effective investment into corrosion monitoring and control management will not only contributed to the cost reduction but will at the same time ensure compliance with safety, health, and environmental policies [9]

In Nigeria, millions of naira are expended yearly in upkeeping and replacement of corroded oil and gas pipelines owing to the reaction of the pipes with their environment. if this situation continues unchecked, a hunk of the country resources will continue to go into corrosion control annually for the purpose of pipeline preservation, replacement, and other ecological related issues. Therefore, there is an urgent need to arrest this scenario via proper design, adequate cathodic protection, and the application of contemporary remote corrosion monitoring methods. According to [10], corrosion monitoring is helpful in measuring the pipelines degradation (integrity) and keeping the system corrosion rate at an acceptable limit through the application of suitable corrosion control techniques. The gravimetry method according to [11], is one of the physical allowable techniques within the industry used in determining quantitatively, the efficacy of cathodic protection using the formula:

$$S_{CP} = \frac{M_O - M_1}{M_O} * 100\% \quad \text{.....1.1}$$

Where M_o is noted corrosion loss of an unprotected steel
M_1 is corrosion loss of a cathodic protected steel.

The corrosion rate [12] calculated using the formula:

$$\text{Corrosion rate (mpy)} = \frac{534W}{DAT} \quad \text{.....1.2}$$

Where mpy is mils penetration per year (umyr^{-1}), W is weight loss (g), D is density (g/cm^3), A is the area (cm^2) and T is time (hours).

GENERAL CORROSION

Corrosion is the unprompted destruction and a degenerative condition of pipelines because of either chemical, electrochemical, or biochemical interaction within the internal or external environment [13], it is a destructive attack on metallic material through chemical or electrochemical reactions within a period of environmental interfacing [14]. Giving a metal electrode within a liquid that comprises ions of the very metal, a potential difference between the metal and the liquid will be form [15].

$$M^{n+} + ne \Leftrightarrow M \text{ .....2.1}$$

M is for metal, M^{n+} is the oxidized metal, ne is the number of electrons.

The potential difference (Pd) can be measured by making comparison with the reference electrode when the Pd within the two points is known. The definitive reference is the standard hydrogen electrode, the potential of which is defined as zero.

$$H_2 \Leftrightarrow 2H^+ + 2e \text{ .....2.2}$$

Taking H_2 as the Hydrogen, H^+ is the hydrogen ion, and e is the electron.
This applied to the general form:

$$a_{Ox} + ne \Leftrightarrow b_{Red} \text{ .....2.3}$$

a and b are taking to be the redox coefficient, Ox is the oxidation, ne is the electrons, while Red is the reduction.

PROTECTION OF OIL AND GAS PIPELINES

It's been recognized that, there are about 528000km of natural gas transmission and gathering pipelines, 1190000km of crude oil transmission and gathering pipelines around the United State of America, and current investigation of major pipelines firms shows that the main reasons behind loss of underground pipelines was because of; (i) coating weakening, about 30% and (ii) insufficient cathodic protection at 20% [16]. The remaining of which is the general system maintenance that is associated with monitoring and repairs of the pipelines.

PREVENTION AND CONTROL TECHNIQUE OF CORROSION

Carbon steel remain the most used steel in pipeline design and construction in the oil and industry. This steel and many others are protected in divers' ways and for a diversity of reasons such as wear resistance, corrosion resistance, lubrication for aesthetic appearance [17]. Both organic and metallic coatings are applied on pipeline to offer protection against corrosion attack on metallic surfaces [18].

Cathodic Protection

Cathodic protection (CP) is considered as the most real and effective method of preventing oxidation of an underground metal structures. This is obtained by imposing between the structures and the ground a small electrical voltage that opposes the flow of electrons and is

stronger than the voltage present in the oxidation process [19]. The cathodic protection is divided into two main methods: the sacrificial anode (galvanic) and the impressed current.

Sacrificial Anode Method

In sacrificial anode or galvanic cathodic protection, the technique employs the natural potential difference (pd) that occurs amid the structure and a second metal within the environment to provide the supplying voltage. The corroding material made the cathode of a galvanic cell, the anode of which is a more reactive metal like magnesium, aluminum, or most cases zinc, which will by being sacrificed, gives protection to the valued structure [20]. No power source is needed, and this is demonstrated in Fig.1. However, the dissolution of this second material (Mn, Al, Zn), the sacrificial anode offers the basis of electrons for the cathodic polarization of the structure.

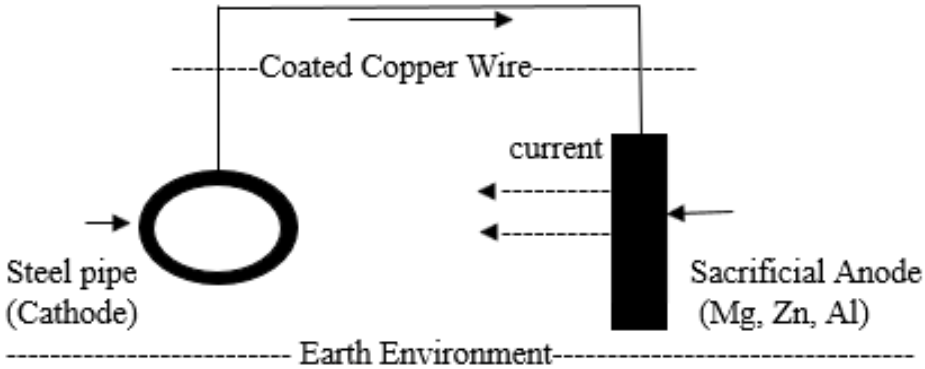

Fig. 1; Underground Pipeline Protection (Galvanic Cathodic)

Impressed Cathodic Protection

The technique of impressed current cathodic protection pedals the corrosion of a metal surface by making it the cathode of an electrochemical cell. This method of fortification links the metal to be protected to a more straightforwardly corroded material "sacrificial metal" to perform as the anode. Impressed current cathodic protection (ICCP) systems are classically mounted to prevent corrosion of metal underground piping systems and associated metal storage tanks. In an impressed current system, current is discharged from anodes sited in the identical electrolyte (soil) in which the piping or tank to be protected are buried. The impressed cathodic protection system needs the installation of an outside power supply which offers a direct current (DC) output as current supply from the alternative source (AC) is erratic and considered not to favor the Cathodic protection [1]. The impressed protection polarization designated by the generator method is presented in Fig.2.

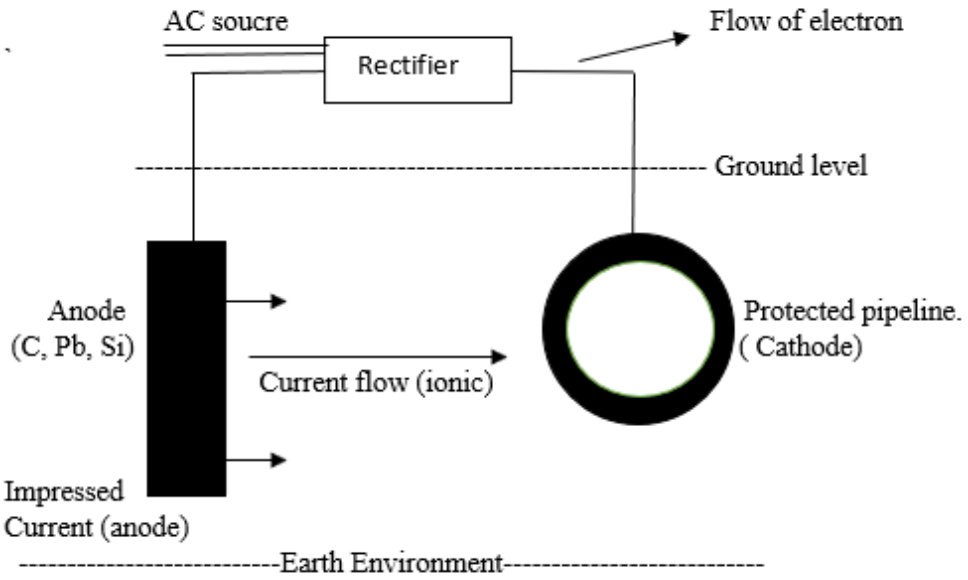

Fig.2, Cathodic Protection with impressed method.

The Cathodic Protection Requirements

There are two known types of electrical power source active in Nigeria and same is obtainable at the site of this work (**ukanafun-calabar pipeline route**) Akwa-Ibom, the renewable energy, and the non-renewable energy sources. The non-renewable will easily run out of used as its supply is limited but the renewable energy source is unlimited, and its supply is ever guarantee. According to the academic contribution of [21], the sun remains one of the renewable energy sources that can be harnessed using Photovoltaic modules.

The Photovoltaic Modules Systems

The photovoltaic (PV) cell, referred to as a solar cell is a solid-state electrical component that produce electricity when exposed to photons, or particles of light and this alteration effect is called the photovoltaic effect. Photovoltaic arrangements provide a suitable and cost-effective solution for the delivery of steady and fairly small amounts of power required for a wide range of application [22]. Photovoltaic systems need no fuel, requires little maintenance input and it is environmentally friendly. This energy system present itself as the only suitable energy option for the provision of electricity at the remote site. According to the reviewed work of [23], solar remote power systems are dependable alternative anywhere the grid power is not accessible.

Stand- Alone PV System

A stand-alone photovoltaic system is an electrical arrangement which consisting of an array of one or more PV modules, conductors as well as electrical mechanisms with one or more load. Stand-alone PV system is a self-sufficient system that is connected to the grid and can have a back-up arrangement. This structure is connected directly to the applicable device and the power is supply during sunshine hours, with a battery storage arrangement to store up power for the night [24,25]. Fig.3. indicate the stand-alone PV arrangement under remote cathodic protection of pipelines.

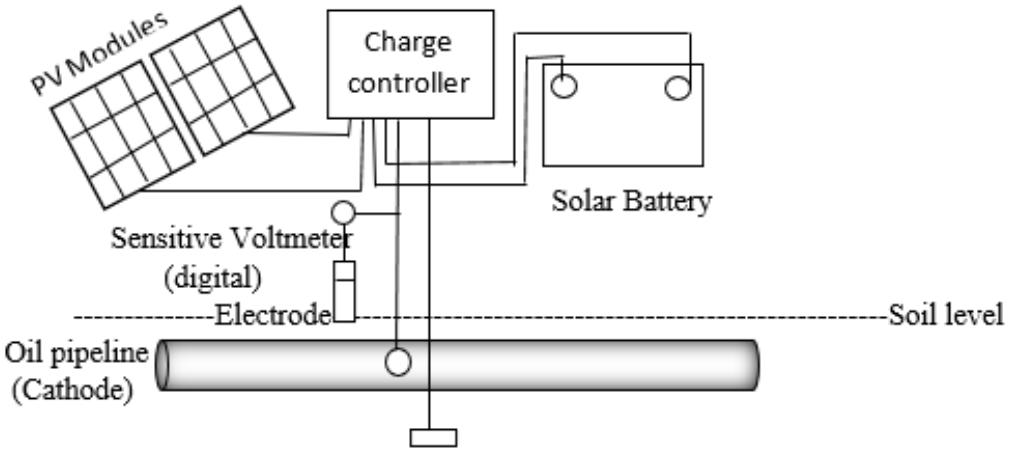

Fig.3. Cathodic Protection of oil Pipeline using PV modules.

Pro-active Monitoring Practices and Cathodic Protection of Oil Pipelines

The Cathodic Protection (CP) techniques are considered the most efficient and effective method of pipeline corrosion monitoring. Applying the modern electronic and communication gadget for isolated monitoring, lessens the operating cost. Located away from the platform, data can be generated and analyzed to aid in the maintenance of the entire system, eliminating waste of resources on manpower and cost of movement associated with the traditional approaches. A digital multimeter is used in monitoring the structure-to-soil potential at the test post. This is instinctive to record figures systematically, to create reports, sense, and report failures at the locations [26]. This remote monitoring or pro-active technique allows industry experts and engineers to monitor cathodic protection arrangements in an isolated location. This method of corrosion monitoring and control is dependable, with the deployment of few manpower, data can be collected from hundred and thousands of locations within a day or days

METHODOLOGY

According to [6], Cathodic Protection methods is design to offer a desired amount of protection at the least total yearly cost over the predictable life of the protected oil pipeline. The material used for the work were provided by the oil firm and the work was carried out under the supervision of Pipeline and Product Marketing Company (PPMC), a subsidiary of the Nigerian National Petroleum Cooperation (NNPC). The design networks were made to the telemetry monitoring circuit, data logger and a laptop computer connected for a real-time, supervising many kilometers away from the location of the oil pipeline Fig.4. The test post was set at every one (1) kilometer apart, where the oil pipeline is cathodic protected from corrosion attack and reading was taken. Electrical measurement, as well as inspection was carried out to certify that the essential protective potential had been established in accordance with the applicable criteria, also that each point of the cathodic protective system function correctly.

The Anode Bed Design Installation's Calculation

The value of a single anode resistance to earth can be calculated using Dwight's equation and the number of anodes required can be established [27]:

$$R_a = {}^{0.1588\rho}_{L}\,[ln^{8L}_{D} - 1] \text{.....1.}$$

R_a represents the anode resistance in ohms (Ω), ρ is the medium resistivity measured in ($\Omega - m$), L is the length of the anode in meter (m) and D is the anode diameter (m). The sum resistance of the anode as well as the ground bed resistance, having in mind the mutual interference is obtained using the Dwight's equation [27].

$$R_{gb} = \frac{R}{N}\left[\frac{\rho}{\pi NS}\right] ln0.66xN \text{.....2.}$$

The ground bed resistance R_{gb} in ohms (Ω), the number of anodes is represented by N, R is a single anode resistance in (Ω) while S represent the anode spacing in meter (m).

To establish the minimum required current for cathodic protection, this is given by.

$$\text{Oil pipeline superficial area} \quad A = \pi(D + 2tw)L \text{.....3.}$$

For minimum current density required is (Ma/m^2). While the modified temperature is (C_1) (A/m^2) The cathodic protection minimum required current is: C_1 x A.

The Cathodic Protection Installation

According to the academic work of [6], the following major points were noted during the process of the installation, Fig.4.,

a) The coke breeze was carefully tamped, as any loose in the backfill can result in high resistance and shortened of the anode lives.
b) The buried connections were secured with extreme defenses from the entrances of any moisture, as a discharge of current to the earth surface from the cable will cause damage to the se-up within days.
c) Cable connection to the anode was protected as any allowable crack will license the entering of moisture that will in-turn give room to system failure.
d) The anodes were suppressed at a satisfactory depth, guarded, against unintended damage

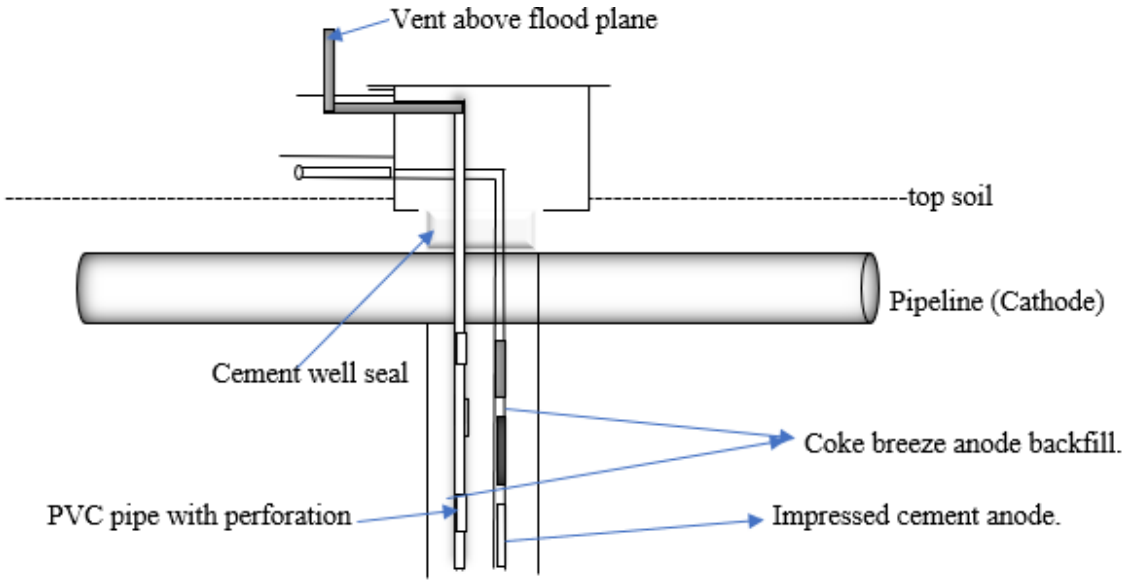

Fig.4: Anode Ground Bed

The installation (pipeline) will be cathodic ally sheltered or protected against corrosion attack. The electrical measurement and review will be carried out to ensure that the required guard potential is established according to the relevant criteria, and that each part of the Cathodic protection system operating correctly, by this remote corrosion is properly checked and the pipeline performance maintained.

The Remote System Network

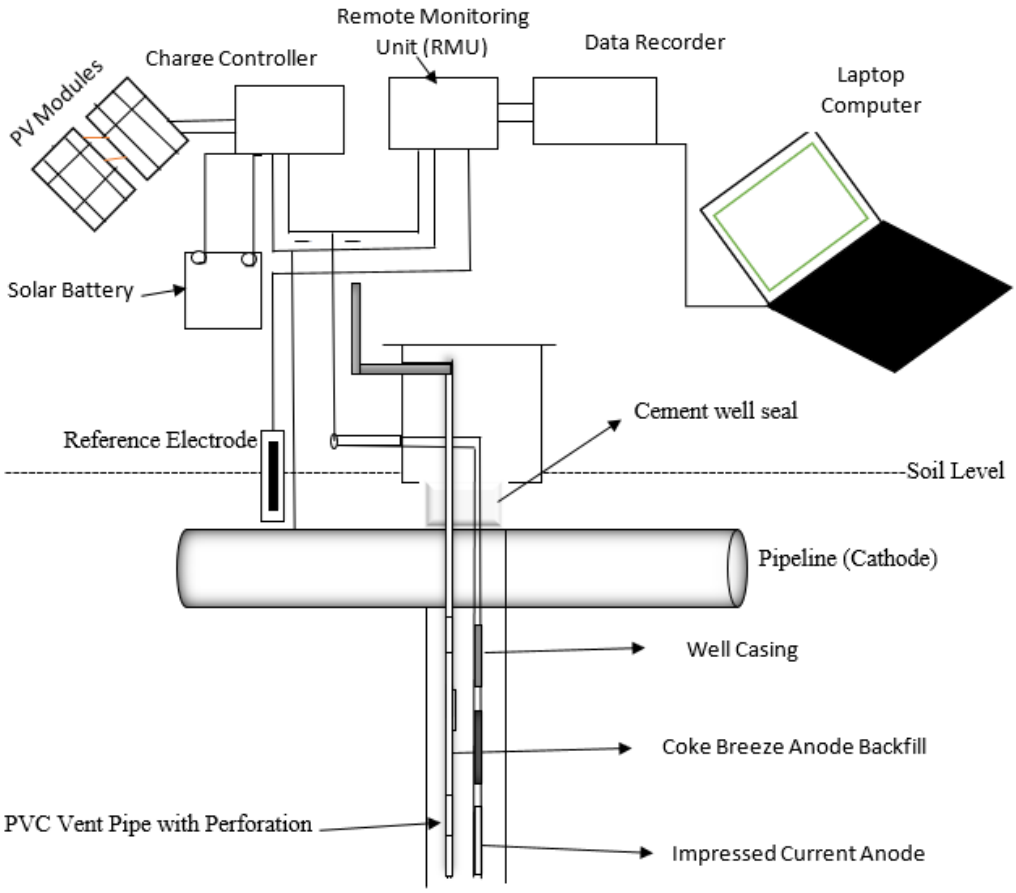

Fig.5. Cathodic Protection and Corrosion Remote Monitoring Component

TEST AND RESULT

At the oil pipeline site of Ukanafun-Calabar NNPC pipeline route, Asang, Akwa-Ibom state, some tests and result of the remote monitoring of pipelines was conducted using telemetry, below is the breakdown of the reading on table 1. and its graphical interpretation on Fig.6. respectively.

Table 1.; Post and Telemetry Cable Pipe-Soil Potentials

Test Post Numbering	Post Pipe-Soil Potential (-mV)	Telemetry Cable Pipe-Soil Potential (-mV)	Difference (mV)
1.	955	955	000
2.	855	857	002
3.	854	842	012
4.	817	836	019
5.	753	758	005
6.	895	893	002
7.	914	945	031

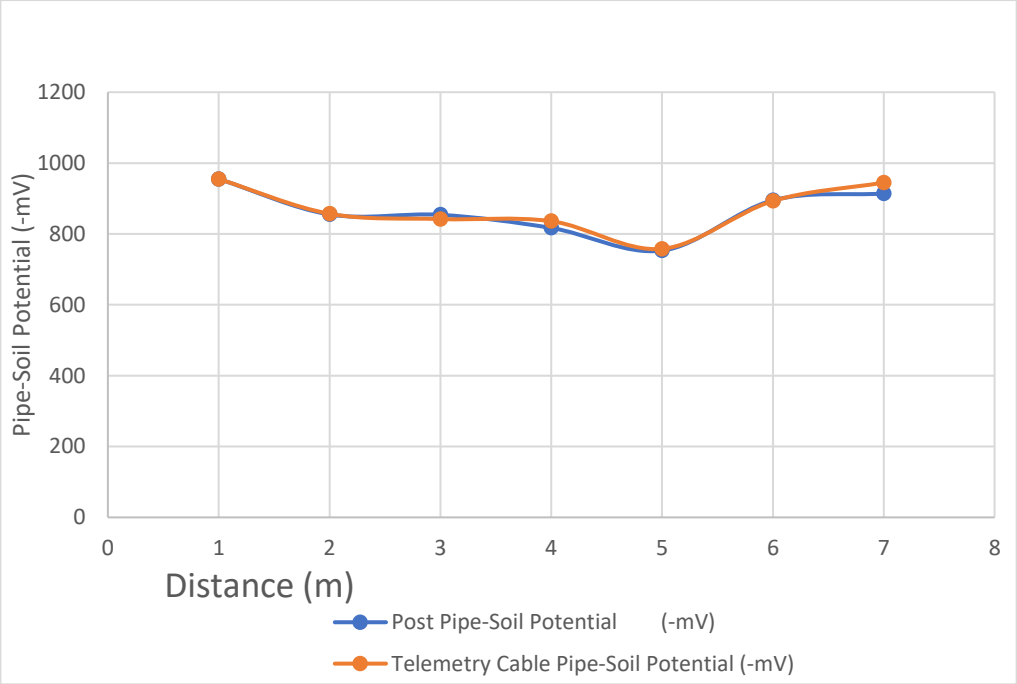

Fig.6.; Post and Telemetry Cable Pipe-Soil Potentials

The above data on Table 1. and Fig.6 display a very close reading with a slight difference among post pipe-soil potentials and telemetry pipe-soil potentials.

From -850 mV, the protection is active and when it goes below -2000mV, it becomes injurious to the pipeline coating system.

CONCLUSION

In the installation, two main methods were setup to run simultaneously, the impressed current and the sacrificial anode. While the sacrificial anode utilizes the corrosive potential created by different metals, the impressed current designates the decreased of the output current because of the anode dissolving into the engrossed saltwater. A steady of power from the photovoltaic cell (solar panel) will maintain a constant check on the corrosion rate of the pipeline but a drop in power supply or an outage will cause a reverse in the protection process.

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