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# An Early Assessment of Open Angle and Normal Tension Glaucoma based on Visual Field Test using Correlation and Association Mapping

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**ABSTRACT**
Analyzing on the different patterns of visual field test gives us suitable medication with the help of perfect assessment. In this study, we establish a predictive assessment, which helps us to make a decision to predict about Open Angle Glaucoma (OPAG) and Normal Tension Glaucoma (NTG) either in the very early stage or possibility of having the disease in the near future. In order to decide the existence of this disease, an associative correlated mapping is designed with linear variables of different ranges like 10-2, 24-2, 30-2 visual field tests patterns. These test patterns consists of different range fields and will be considered as linear variables. All these levels are compared and analyzed with degree of correlation on limit range values to produce outcome. By using this knowledge, the final result will be assessed for both left eye and right eye separately. The final comparative analysis will assess and produce possible accurate result for decision making by clinicians.

**Key words**:Correlation ,Normal Tension, Glaucoma (NTG), Open Angle Glaucoma, Visual Field Defects

## 1. INTRODUCTION

Glaucoma is a wide spread chronic disorder and it has apparently occupied the leading position in the occurrence of the disease due to the macular degeneration. Macular Degeneration is the leading cause of vision loss, affecting more than 60 million people worldwide which is more than cataracts and glaucoma combined together[1]. At present, Macular Degeneration is considered an incurable eye disease [2]. Macular Degeneration is caused by the deterioration of the central portion of the retina, the inside back layer of the eye that records the images we see and sends them via the optic nerve from the eye to the brain. The retina's central portion, known as the macula, is responsible for focusing central vision in the eye, and it controls our ability to read, drive a car, recognize faces or colors, and see objects in fine detail. Senior citizens mostly affected by Glaucoma initially in the African and American countries[3]. But, gradually it has become known and popular and getting place mostly all over the world[4]. There are more chances to get glaucoma now a days, especially with people aged over 40. Due to the changes in the life style in all aspects, people are getting chronic eye diseases in the middle age because of over straining the eye by using different electronic devices to get

damage for optic nerve of the eye[2,5]. Basically, visual field defects in the primary stage can be identified by patient and this is one of the important diagnosis to get correct medication by clinicians. While diagnosing initial visual field defects, the result may be positive indicating glaucoma or non glaucoma [6-7]. The fundamental concept of this paper is to take decision about the occurrence of glaucoma in the near future or in its early stages. This needs a proper examination by the clinician and having a better tool to diagnose the disease in the primary stages is definitely a boon for a clinician especially in identifying the visual test patterns. In this research, our study will give an idea about all VFs test patterns for different defects like central visual field defect, paracentral defects, blind spot area, nasal step defects, wide angle defects etc [8-9]

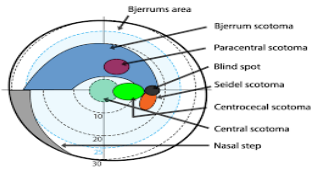


**Figure1:** Basic structure of isopter and cotoma in different visual fields.

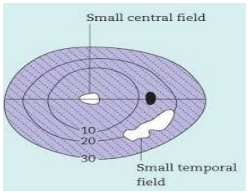


**Figure 2**: Locations of blind spot and temporal fields and covered field areas

It is necessary to examine about visual field first because, it is the initial phase to determine about the possibility of glaucoma in the early stages[10]. If it becomes success then there are more chances to get cured with in the time span with 100% accuracy. Expenses for medication will become less and the growth percentage of advanced glaucoma patients will be

reduced gradually. Later, the diagnosis will depend upon optic nerve and cup segmentation [11].

Analyzing different patterns of open angle Glaucoma and Normal Tension Glaucoma to predict the possibilities of occurrence of the disease is pertinent in very early stages[12]. Variable Delta VF plays major role initially in the tests to predict early stage of Glaucoma or any eye disease called VF tests. These contain 10-2(10), 24-2(24), 30-2(30) ranges are named as central, medium and wide ranges respectively[13].

In this paper, we discuss about prediction of early stage glaucomatous eye for either left or right eyes or both eyes as well. The baseline test for assessment of any eye disease is visual field test(VF Test) and this is mandatory test to any person who is suffering with any basic eye problems[14] During this test, clinicians will approach with different ranges and patterns. Among many VF Tests, The central vision field test (10-2)[15] is the main test and the results of which gives us more possibilities of Glaucoma. The 24-2 test is also called as a standard test by Goldmann perimetry as it deals with accuracy in diagnosing diseases[16].The wide area test 30-2 helps us to take decision by producing accurate results[2]. All these mentioned visual tests are to be correlated with the association mapping to provide good analysis and proper decision.

## 2. RELATED WORK

The work related to the prediction of early stage of glaucoma is initially based upon the area of visual field defects. Şerife Seda KucurID*, Ga ´bor Hollo , Raphael Sznitman have investigated the suitability of multi-scale spatial information in $30^o$ visual fields (VF), computed from a Convolutional Neural Network (CNN) classifier, for early-glaucoma vs. control discrimination using OCTOPUS 101 G1 program and the Humphrey Field Analyzer 24–2 patterns to discriminate between control and early glaucomatous eyes. The proposed CNN offers high classification performance for the discrimination of control and early glaucoma.

IlanaTraynis;CarlosG.DeMoraes;AliS.Raza,BA;JeffreyM.Liebmann;RobertRitch;DonaldC.Hood determined the prevalence and characteristics of visual field(VF)defects in the central 10° in glaucoma suspects and patients with mild glaucoma[15,17].

Koji Nitta1, Ryotaro Wajima, Gaku Tachibana1,, Sachie Inoue,et.al have established a predictive formula for glaucomatous visual field progression in patients with Primary open-angle glaucoma, mainly including normal tension glaucoma. The discriminative ability of the formula was evaluated as moderate performance using receiver operating characteristic analysis, and the area under the curve was approximately 0.75 at all cut-off values[18]

Ananth C Viswanathan, Fred W Fitzke, Roger A Hitchings have compared the performance of PROGRESSOR (pointwise linear regression) and STATPAC 2 (comparison with baseline values) in detecting early deterioration in the visual fields of glaucoma patients[19]. Sreelekha Panda, Satya Sis Mishra, Mana Ranjan Senapathi have developed detection and classification methods for EEG epileptic seizures[20]. Similarly, A. Nagarajan and J.vasanth Wason have used an Machine Learning approach to predict Lung Cancer using CT Scan Images[21]. Venubabu Rachapudi,T.Krishna Sai,S.Hari priya and K.Pushpahas have developed an effective approach to classify retinal images for diabetic retinopathy[22]. Similar work related to diabetic retinopathy detection and grading was performed by Kirange et.al.[23] using machine learning approach. Machine learning techniques have also been implemented in predicting the ductal carcinoma by S,uddaraju and M R Narasingarao[24]. Similar works have also been implemented by T.Sajana and M R Narasingarao for classification of Malaria disease[25]. A comparative study of machine learning was also implemented by Deepthi Gurram and M R Narasingarao in predicting the thyroid disfunction [26] in predicting the disease.

## 3.METHOD

To establish the mapping rules, degree of correlation has been used for the purpose. The ranges in the different visual field are considered as straight line variables and these are referred as linear variables . To examine the intensity of each visual field effect degree of correlation is considered. The performance of the pattern standard deviation (PSD) values derived from the central 12 locations of the 24-2 visual field test (C24-2) with respect to the entire 10-2 test for detecting central visual field abnormalities in eyes with, suspected of having, or at risk of having glaucoma. Eyes with, suspected of having, or at risk of having glaucoma, based on masked grading of optic disc stereophotographs and/or ocular hypertension (intraocular pressure $\geq$ 22 mm Hg) and the sensitivity to detect cases at 95% level specificity using PSD values derived from the entire 10-2 test and C24-2 were compared.10-2 and 24-2 tests identified a similar number of eyes with, suspected of having, or at risk of having glaucoma as having central visual field abnormalities using PSD values. It is also concluded that, these findings do not mean that 10-2 tests are not useful, but highlight the need for further studies to determine the potential advantages of 10-2 tests through equivalent comparisons against 24-2 tests to ensure appropriate recommendations are made about its incorporation into the glaucoma standard of care[12,21].Later the most appropriate 30-2 test of wide area is conducted to and associated with previous outcomes of 10-2 and 24-2.

Here, we use consider different test cases and their relationships among the test regions of interest.

**Case I**: 10-2 test may be Normal and 24-2, 30-2 tests may be Abnormal

**Case II**: 10-2 test may be Abnormal and 24-2,30-2 tests may be Normal.

**Case III**: 10-2, 24-2 tests may be Normal and 30-2 test may be Abnormal.

**Case IV**: 10-2,30-2 tests may be Normal and 30-2 test may be Abnormal.

**Case V**: 10-2, 24-2 tests may be abnormal and 30-2 test may be Normal.

**Case VI**: 10-2, 24-2 tests may be Normal and 30-2 test may be Abnormal.

From the above cases we can observe that performance of each individual test cases and the relationship among test regions. For example 10-2 region of Central Visual Field shows normal at isopter but 24-2 shows the stable of abnormal at blind spot or nasal step defect[22]. The paracentral defects have 2 types superior PD and inferior PD at the same time Nasal Steps have Superior Nasal Step SND and Inferior Nasal Step IND. All the should be considered and while examining eye field at any narrow area will get positive value. So, the coverage of central, medium, wide Visual fields is crucial to analyze to encounter the defect. Illustration of normal and abnormalities in the different Visual field test ranges by comparing 10-2 and 24-2 Test Fields.

**Table 1:** Shows two possible ways of 10-2 and 24-2 compared and given prediction using limit $\square_{1(limit)}$

| 10-2 | 24-2 | $\square$1 (limit) |
|---|---|---|
| Normal | Normal | No Correlation |
| Normal | Abnormal | Moderate |
| Abnormal | Normal | Moderate |
| Abnormal | Abnormal | Perfect |

**Table 2:** Comparing 24-2 and 30-2 Test Fields shows two possible ways of 24-2 and 30-2 compared and given prediction using limit $\square_{2(limit)}$

| 24-2 | 30-2 | $\square$2 (limit) |
|---|---|---|
| Normal | Normal | No Correlation |
| Normal | Abnormal | Moderate |
| Abnormal | Normal | Moderate |
| Abnormal | Abnormal | Perfect |

**Table3:** Comparing 30-2 and 10-2 Test Fields : Shows two possible ways of 30-2 and 10-2 compared and given prediction using limit $\square_{3(limit)}$

| 30-2 | 10-2 | $\square$3 (limit) |
|---|---|---|
| Normal | Normal | No Correlation |
| Normal | Abnormal | Moderate |
| Abnormal | Normal | Moderate |
| Abnormal | Abnormal | Perfect |

$X \wedge Y \rightarrow \wp_1$ : $Y \wedge Z \rightarrow \wp_2$ : $Z \wedge X \rightarrow \wp_3$

The next level of correlating any two variables is continued with the help of association mapping between correlated value and new variable value.

Explanation for Association Level.:

If X & Y are considered then $\wp_1$ will be associated and correlated with $\omega 3$

If Y & Z are considered then $\wp_2$ will be associated and correlated with $\omega 1$

If Y & Z are considered then $\wp_3$ will be associated and correlated with $\omega 1$

$\rightarrow (\wp_1, \omega 3) V (\wp_2, \omega 1) V (\wp_3, \omega 2)$ Produces outcome of this correlation .

Expressing in terms of Pearson Degree of Correlation including limit range values on linear variables:

1.Limit: [-1,1]

2. Pure Number: different scales

3. Symmetric: X→Y== Y→X

The Limit ranges obviously from -1 to 1 always .If we assume -1 is negative and NO PERFECT then +1 tends to positive and POSITIVE. Pure number can be different with scales between any two variables can be considered. Symmetric property occurs if correlation value is between two variable is always same from X→Y and Y→X. In our study among these properties the suitable one for our prediction toward eyes with visual defects and without visual defects is Limit property. For each examination of visual field range 10-2, 24-2, 30-2

The measurements will come either NORMAL or ABNORMAL. If it is normal the value is almost reaches to -1. If it is abnormal the value almost reaches +1. Further the variable (X,Y) or (Y,Z) or (Z,X) are correlated and reaches any value between -1 and +1.

Degree of correlation: According pearson degree of correlation, The above limit values taken as sub ranges.

**Table 4:** Ranges and degree of correlation

| Degree | Value | Type of Correlation |
|---|---|---|
| Perfect | +1 | Perfect |
| High | lies between ±0.50 &± 1 | Strong |
| Moderate | lies between ±0.30 &± 0.49 | Medium |
| Low | lies between ±0 to & ± 0.29 | Small |
| No | when the value is 0 | No Correlation |

The above Table contents are sufficient for comparing any two variables of visual field test ranges. Suppose first of all if 10-2 (X) and 24-2(Y) will be considered after examining and conducting a particular test in eye clinic by a clinician these can be treated as input values to our specific correlated variable initially .Let us take in the following format of Normal (0.0), Abnormal(+1). Further more values will come with the comparison of $X \wedge Y$ , (ie)

**Case I**: If Normal & Normal compared that implies Normal only the outcome is 0.0.( If 10-2(X) and 24-2(Y) both are normal then result is normal).

**Case II**: If Normal and Abnormal are compared probably Strong correlation and outcome is nearly 0.5.(If Visual field

defect in 10-2 is normal and Visual Defect in 24-2 is Abnormal then the result is strong correlation.

**Case III**: If Abnormal and Normal are compared again strong correlation is possible and the outcome is nearly 0.5.(If visual Field defect in 10-2 is abnormal and 24-2 is normal then the result is strong correlation.

**Case IV:** if Abnormal and Abnormal are compared then there is clear possibility of +1 only. (If 10-2 and 24-2 both abnormal the result is perfect correlation).

**Table 5:** □1(limit)correlation and related association with ω3

| **10-2(X)** | **24-2(Y)** | **□1(limit)** | **Correlation Assumption** | Outcome | ω3 |
|---|---|---|---|---|---|
| N | N | ±29 to 0.0 | -ve | NoC | Normal ±0.29 to 0<br><br>Abnormal +1 |
| N; | Ab | -0.30 to +0.30 | +ve | Strong | |
| Ab | N | +0.30 to -0.30 | -ve | Strong | |
| Ab | Ab | +1 | +ve | Perfect | |

According this association outcome is sufficient to analyze the Visual Field Defects in the very early stage of glaucoma the major 3 test were successfully done and all three are correlated and associated in the systematic approach Further the above association map will produce the following possible combinations.

**Table 6**: Illustration of association from □ to ω. Level of degree after association**.**

| □11 → ω3 | | Outcome |
|---|---|---|
| □0.0 | ω 0.0 | Normal |
| □0.5 | ω 0.0 | High Degree |
| □0.5 | ω 0.0 | Moderate |
| □+1 | ω 0.0 | Strong |
| □0.0 | ω+1 | High Degree |
| □0.5 | ω+1 | Strong |
| □0.5 | ω+1 | Strong |
| □+1 | ω+1 | NoC |

This approach can be rotated among these variables if 30-2 and 10-2 correlated first then associated with 24-2 (ie) Z-→X and □$_3$→ ω2.

If variables if 24-2 and 30-2 first correlated the associated with 10-2. (ie) Y→Z and □$_2$→ ω1.

**VFS range mapping algorithm on Correlation and Association among X→Y→Z:**

**Step 1**: Apply 10-2, 24-2 methods to find VF test patterns. Apply later 30-2 method to get the result where the result can be Normal and Abnormal

**Step 2**: store variables x,y,z for 10-2,24-2 and 30-2 VF methods along with outcomes Normal and Abnormal

**Step 3**: correlate x→y, y→z, z→x (Any one is required at least ) using Karl Pearson linear correlation between any 2 variables.

**Step 4**: Make □$_1$, □2 and □3 as coefficient variables in an order

**Step 5**: Get outcomes here for □$_1$, □2 and □3 respectively as chances of N(Normal), AB(Abnormal), HD(High Degree) and Moderate using correlation range values. By the comparison of ranges we give values to the results.

**Step 6**: Further, the above generated results are produced by comparing the Karl Pearson Correlation Coefficient between □$_1$→z, □2 →x and □3 →y and denote it by ω1,ω2 and ω3.

**Step 7**: ω1,ω2 and ω3. are the final comparison values after correlation with association.

**Step 8**: we can consider the result as follows:

Result1→ ω1 implying □$_1$→z
Result2→ ω1 implying □2→x
Result3→ ω3 implying □3→y

**Step 9**: Now conclude with the support of either Result1or Result2 or Result3 as Normal(N), AB(Abnormal), HD(Strong) and M(Moderate)

**Step10**: repeat the same process for right eye also.

Store the left eye values in D1 and similarly repeat teps from 1 to 9 for store the values of right eye in D2 .

## 4.RESULTS

The Final outcome table for VF test can be as follows using linear variable Correlation.

**Table 7:** Illustration of final outcome for decision support system to compare left eye and right eye limit ranges and degree of correlation

| Left Eye | | Right Eye | | Outcome |
|---|---|---|---|---|
| Normal | 0.0 | Normal | 0.0 | Pure |
| Abnormal(AB) | +1 | Normal | 0.0 | Moderate |
| Moderate(M) | 0.3 | Normal | 0.0 | Low degree |
| High Degree(HD) | 0.5 | Normal | 0.0 | Low degree |
| Normal | 0.0 | Abnormal (AB) | +1 | Moderate |
| Abnormal(AB) | +1 | Abnormal (AB) | +1 | Perfect |
| Moderate (M) | 0.3 | Abnormal (AB) | +1 | Strong |
| High Degree (HD) | 0.5 | Abnormal (AB) | +1 | Strong |
| Normal | 0.0 | Moderate (M) | 0.3 | Low degree |
| Abnormal (AB) | +1 | Moderate (M) | 0.3 | Strong |
| Moderate (M) | 0.3 | Moderate (M) | 0.3 | Low degree |
| High Degree (HD) | 0.5 | Moderate (M) | 0.3 | Moderate |
| Normal | 0.0 | High Degree | 0.5 | Low degree |

| | | | | |
|---|---|---|---|---|
| | | (HD) | | |
| Abnormal(AB) | +1 | High Degree (HD) | 0.5 | Strong |
| Moderate(M) | 0.3 | High Degree (HD) | 0.5 | Moderate |
| High Degree(HD) | 0.5 | High Degree (HD) | 0.5 | Strong |

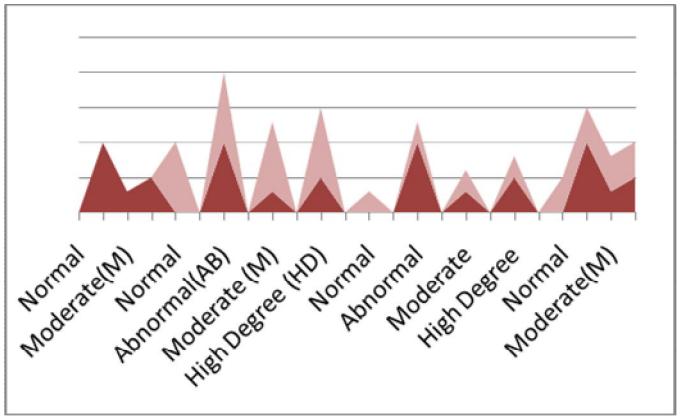


**Figure 3:** Illustration of all 16 possible right eye and left eye limit range values at final process after association with correlation in a parallel manner

**5.DISCUSSION**:

Visual Field tests definitely gives a +ve support and best reference to the later examinations like Optic Nerve Disc and Cup segmentation analysis etc[11].This methodology tried to give a simplified and systematic approach to support clinicians and fresh trainees with maximum effort make almost perfect decision in a convenient manner. This is the phase I test which helps surely to predict very early stage of possibility of Primary Open Angle Glaucoma [18] or Normal Tension Glaucoma or the possibility of occurrence Glaucoma in the near future [10]. Another point is, this initial Visual Field test also directs the possibilities of other eye disease. This work will suggest and provide clear platform for simplifying eye tests of VFs in different regions[13].

The objectives of performing Visual Field test regularly and analyzing these is to reduce number of glaucoma patients with advanced stage near the future. Because advanced stage of glaucoma is most dangerous and sometimes may lead to complete blindness for a patient. For this reason, we need to take up the following steps in a definite manner and need to guide patients to appear for regular examinations .and medications.

1. Regular visits and performing tests.
2. Early Diagnosis which is mostly curable
3. Perfect Decision Making
4. Correctness in the treatment.

**Table 8:** Nomenclatures and Abbreviations

| Nomenclatures | |
|---|---|
| X | linear variable for 10-2 test field. |
| Y | linear variable for 24-2 test field. Z: linear variable for 30-2 test field. |
| □1 | limit range from X to Y |
| □2 | limit range from Y to Z |
| □3 | limit range from Z to X |
| ω1 | Association variable for Y➔Z |
| ω2 | Association variable for Z➔X |
| ω3 | Association variable for X➔Y |
| ABBREVIATIONS | |
| N | Normal |
| AB | Abnormal |
| P | Perfect Correlation |
| HD | High Degree |
| LD | Low Degree |
| M | Moderate |

**6.CONCLUSION**

This prototype model can help as a tool for Medical practitioners to make correct decisions .This decision support system described in this paper is an analyzed, designed, implemented in a systematic approach. By identifying the early stage of Glaucoma, we can mitigate the advancement of the disease at an early stage.

**Future work:** This work can be further implemented and extended to Optic Disc and Cup Segmentation test analysis as a phase II to predict open angle in early or moderate stage.

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