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1ST ISSUE

ADAPTIVE REGRESSION SPLINE APPROACH ON COMPLAINTS EYE FATIGUE CRAFTSMEN MAKARAWO IN GORONTALO PROVINCE

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ABSTRACT

The purpose of this study is to examine the factors that affect eye fatigue complaints by craftsmen. Results of the study with adaptive regression splineapproach showed that eye fatigue complaints by craftsmen influenced by over 17 years of age followed more than 270 lux intensity, the level of primary and secondary education followed by the volume of the room is less than 101.7 m^3 sizing workless than 0.4 m^3, light intensity of more than 270 lux, temperatures below 32.4°C followed by a light intensity of more than 270 lux, visibility of more than 15 cm, working period of 2 years followed by a light intensity of more than 270 lux.

Key words: Eye fatigue, complaints, adaptive regression spline, light intensity

1. INTRODUCTION

In Indonesia there are various types of folk handicraft industry in very many scattered in remote villages and each develops according to environmental conditions and local culture. In general, the villagers are farmers, while as a side income one is working as a craftsman. Not a few people who Sentra Handicraft progress in its efforts so as to improve the standard of living of local communities. Efforts to improve the quality and productivity in order to have a good competitiveness on a national and international scale is the duty of every Indonesian. If efforts to increase productivity and quality and do not start now, then our nation will fall further behind, especially facing an increasingly uncertain economy, thus improving the quality and productivity movement is something that can not be negotiable [1].

In the province of Gorontalo, small industry and handicrafts emerging filigree handicraft industry which is generally carried out by women. Openwork peyulaman process requires precision and persistence and good lighting in order to get the beauty of motifs and embroideries. Lighting according to the needs and activities conducted, both indoors and outdoors, will provide visual comfort in humans. Visual comfort that is created it would have an impact on the visual perception of the room, as well as a variety of visual objects therein. Visual perception, or the human response to visual conditions that are accessed by the visual senses, strongly influenced by light because cahayalah which allows us to access visual information. To that end, it is important to be able to meet the demand for light accurately and in accordance with the needs of a space, both inside and outside space space. Lighting workplace poor directly will not cause damage to the eyes, but often cause fatigue and discomfort in the eye. While the lighting or lighting that is too strong (too high lighting intensity) is also undesirable because this situation can cause glare.

Lighting or illumination in a field is the flux of light falling on 1m² from the field, [1]. Unit for the intensity of illumination is lux (lx) and the symbol E. So 1 lux = 1 lumen per m^2. Light seen by the eye or visible light radiation in a segment of the electromagnetic spectrum that lies between infrared and ultraviolet segment, having a wavelength 10^{-6} to 10^{-7} cm and frequency 3 x 1014 to 3 x 1015 cicle per second [3].

Lighting (illumination) by [8] is the amount of light falling on a surface. Lighting is everything that relates to light in relation to visual function in the work, including the quality and quantity. One unit is associated with the lighting of candles, lumen (lm), lux (lx), wax / m. Wax is a unity power of the light source. 1 Lumen is anuys light emitted from the light source over 1 candela in steradial. 1 Lux is a light field that field 1m each receive light.

Lighting intensity is the amount of light arriving at a surface area [3]. Based lighting source is divided into three, the first natural lighting is lighting that comes from the sun, the artificial lighting is lighting that comes from light, and the third is the natural and artificial lighting that is a merger between the natural light of the sun with a light / artificial lighting [9].

According to Ching [8], there are three methods of illumination, namely: general lighting, local lighting and illumination light accents. Diffuse general lighting or illuminate the room evenly and generally feels diffuse. Local lighting or illumination for specific uses, partially illuminating the room with a light source is usually mounted close to the illuminated surface, while the accent lighting is a form of functioning local lighting illuminates a place or a particular activity or object of art or other valuable collections.

In relation to activities undertaken filigree artisans, it is necessary to assess the optimal illumination (TOHEREN) against eye fatigue complaints based measurement craftsman will affect the productivity of craftsmen karawang Gorontalo district with MARS approach [6][7][10][11]

2. RESEARCH METHODOLOGY

This study was conducted cross-sectional, conducted through three stages: observation and study of references about filigree artisans industrial lighting systems. Observation and study of reference in the first stage form the basis of interview guidelines to determine the optimum illumination factor variable (TOHEREN) on filigree artisans Gorontalo district [4][5]. Assessment of the level of accuracy of eye fatigue as a result of interviews with respondents using Flicker Frequency gauges. Determining the Information System model Toheren (Iohe Makarawo Ergonomics) on filigree artisans in the district of Gorontalo. Eye fatigue complaints by craftsmen karrawang influenced by the characteristics (age, education, past work and working time), illumination, glare, direction of light, shadow, color, visibility and temperature) [2][3]. More details are presented role in the framework of the concept of research.

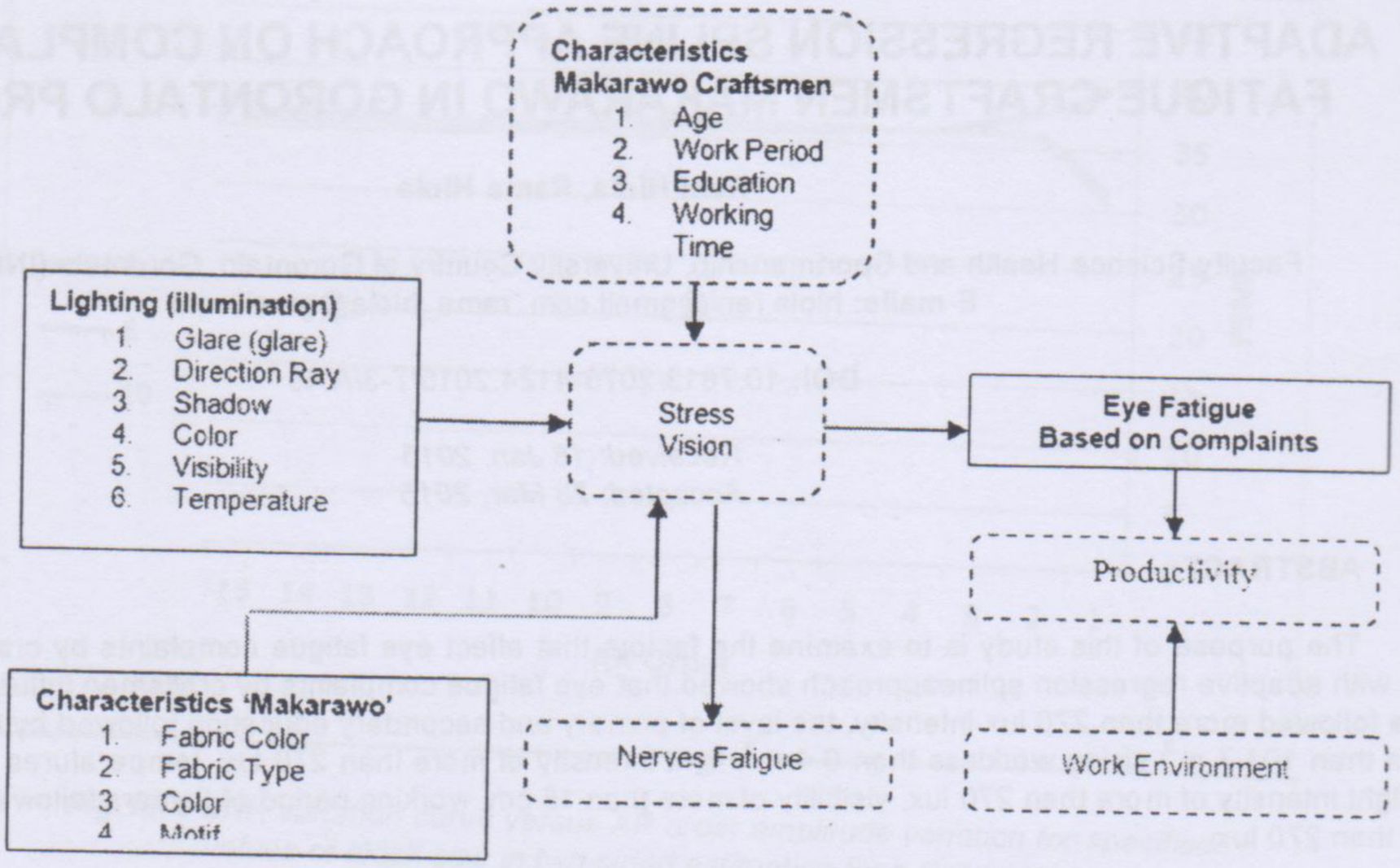

Fig. 1. *Framework Research Concept Eye Fatigue Based on Complaints*

The first step, conducted a descriptive statistical analysis of the variable-veriabel perdiktor. Second, to determine the factors that influence eyestrain based on complaints, how patterns of relationship, do the following procedure. [12][13][14][15]

1. ARS model building for the initial set of data: (1) determining BF; (2) determining MI; (3) determining MO between knots.
2. Getting the best MARS models for single dataset based on the value of the smallest GCV.
3. Obtain significant variables influence of ARS best models for a single dataset.

ARS was introduced in 1991 by Friedman [7]. ARS model is useful to overcome the problems of high dimension of data and produce accurate prediction of the response variable, and generate a continuous model in knots by GCV smallest value [10].

ARS general model equation can be written as follows [6][10]:

$$f(x) = \alpha_0 + \sum_{m=1}^{M} \alpha_m \prod_{k=1}^{K_m} [s_{km} \cdot (x_{v(k,m)} - t_{km})]_+ + \varepsilon_i$$

where,

α_0 = constant basis function (*constant basis function*),
α_m = coefficient ofbasis functionto-*m*,
M = maximum basis function (*non-constant basis function*),
K_m = interaction degree,
s_{km} = worth 1 if the data is on the right point knots, or -1 if the data is valuable to the left of point knots,
$x_{v(k,m)}$ = predictor variables, and
t_{km} = knot value of predictor variables $x_{v(k,m)}$.

ARS can find the location and number of knots required in a step forward / backward stepwise [10]. Forward stepwise done to get the function with the maximum number of basis functions. The criteria for selection on the forward stepwise basis functions is to minimize Average Sum of Square Residual (ASSR). Meanwhile, to meet the concept of parsimony (the model as simple as possible with minimal variable) is done backward stepwise, aiming to select the function base resulting from the forward stepwise by minimizing the value of GCV [7][10].

MARS determine the optimal models among other models is to select the model that has the lowest GCV value. GCV criteria introduced by Wahba, 1979 in [10]. Minimum GCV function is defined as:

$$GCV^*(M) = \frac{ASR}{[1 - \frac{C(M)^*}{n}]^2} = \frac{\frac{1}{n}\sum_{i=1}^{n}[y_i - \hat{f}_K(x_i)]^2}{[1 - \frac{C(M)^*}{n}]^2}$$

where:

K = number of basis functions(*nonconstant* basis function) which is determined in step forward
x_i = predictor variables
y_i = response variables
n = number of observations
$C(K)^* = C(K) + dK$
$C(K)$ = Trace $[B(B^TB)^{-1}B^T]+1$
d = value when each basis function achieve optimization$(2 \leq d \leq 4)$

3. RESULTS AND DISCUSSION

Characteristics craftsmen makarawo consists of eyestrain, the lighting / light intensity (illumination level), the shadow, the direction of light, wall color, visibility and age. Descriptions of each variable research is as follows.

Table 1. Description of 'Makarawo' Craftsmen At Eye Fatigue Based on Craftsmen Complaints

Variable		Distribution	
		Frequency	Percentage (%)
Eye Fatigue Based on Complaints	Not Tired	26	36.6
	Tired	45	63.4

Table 1 shows that the craftsman filigree work based flicker fusion before giving an average of 0.8056 with a standard deviation of 0.10782. This shows that the filigree artisans before work did not experience eye fatigue, because the average value of more than 0.6. While artisans filigree work based flicker fusion after giving an average of 0.5810 with a standard deviation of 0.0670. This shows that the craftsman kerrawang after work eyestrain, because the average value of less than 0.6 and is relatively homogeneous. In addition it appears that in the filigree artisans work an average of areas of work that are used for 0.945 m2 with a standard deviation of 1.366 m^2.

Table 2. Description of 'Makarawo' Craftsmen Based onContinuousType Variable

Variable	Statistic			
	Minimum	Maximum	Mean	Standar Deviasi
Age	20	39	29.676	4.947
Working Time	1	3	1.662	0.533
Makarawo Completion Time	1	2	1.859	0.350
Light Intensity	30	400	149.010	99.773
Visibility	15	35	25.985	8.644
Temperature	30	33.2	32.142	0.524
Work Period	5	25	12.648	4.846
Room Size	22.8	103.9	55.366	23.637

Table 2 shows that the craftsman filigree most 20-year-old and the 39 year old world, while the average age of 30 years with a standard deviation of 5 years. This shows that age is the age of the filigree artisans productive at work. The table also shows that the craftsman has filigree work time at least 1 hour and up to 3 hours, while the average working time of 1.662 hours with a standard deviation of 0.533 hours. This indicates that the filigree craftsmen working time tends to be normal. Furthermore engrajin has openwork filigree completion time at least 1 hour and up to 2 hours, while the average completion time openwork 1.8592 hours with a standard deviation of 0.35034 hours. This indicates that the turnaround time is quite fast filigree. Seen that visibility is also the smallest used filigree artisans by 15 cm by 35 cm and the largest, while the average of 26 cm with a standard deviation of 9 cm. This shows that the craftsman filigree work using the average visibility is 26 cm.

From the table it appears that most small temperature used for filigree artisans 300° C and most of 33,2°C, while the average for 32,14°C with a standard deviation of 0,53°C. This shows that the craftsman filigree work using temperature is not appropriate because more than 28°C. The table shows that the smallest lighting used filigree artisans largest of 30 lux and 400 lux, whereas an average of 149.01 lux with a standard deviation of 99.773 lux. This shows that the craftsman filigree work is still not using appropriate lighting, because the average value of less than 300 lux. The table shows that the filigree craftsmen who have a tenure of at least 5 years old and 25 years, while the average tenure of 13 years with a standard deviation of 5 years. This indicates that artisans had long filigree work. The table shows that the craftsman filigree work has the smallest room size 22.8 $m^3$and the maximum 103.9 m^3, while the average room size of 55.366 $m^3$with a standard deviation of 23.637 m^3.

Table 3. Description of Makarawo CraftsmenBased on Discrete TypeVariable

Variable		Frequency	Percentage (%)
Glare	Not Glare	24	33.8
	Glare	47	66.2
Direction Ray	Appropriate	37	52.1
	Not Appropriate	34	47.9
Glare Cloth	Chiffon	27	38.0
	Tapeta/Silk	44	62.0
Wall Color	White	57	80.3
	Colored	14	19.7
Using Glasses	Yes	22	31.0
	No	49	69.0
Makarawo Color	1 Beige	17	23.9
	2 Pink	18	25.4
	3 Black	31	43.7
	4 Yellow	5	7.0
Makarawo Motif	1 color	17	23.9
	2 color	18	25.4
	3 color	26	36.6
	4 color/more	10	14.1
Education	SD	12	16.9
	SMP	24	33.8
	SMA	33	46.5
	S1	2	2.8
Glare	Not Glare	24	33.8
	Glare	47	66.2

Table 3 shows that the percentage of working filigree artisans in most of the states glare in the work that is equal to 66.2 percent and the rest is not dazzled by 33.8 percent. The percentage of working filigree artisans in most of the direction of light equal to or more than 30 degrees is equal to 52.1 percent and the rest is not appropriate or less equal to 30 degrees at 47.9 percent. The percentage of working filigree artisans in most of the use of fabrics tapeta / silk is equal to 62.0 percent and the rest kind of chiffon by 38.0 percent. The percentage of working filigree artisans in most of the walls white color that is equal to 80.3 percent and the rest is colored by 19.7 percent. The percentage of artisans in filigree work mostly do not wear glasses in the amount of 69.0 percent and the rest wearing glasses at 31.0 percent. The percentage of working filigree

artisans in most of the use of color filigree type 3 is equal to 43.7 percent and the rest use color filigree type 2, 1 and 4 respectively by 25.4 percent, 23.9 percent and 7 percent. Table 3 also shows that the percentage of working filigree artisans in most uses three types openwork motif that is equal to 36.6 percent and the rest used filigree motifs type 2, 1 and 4 respectively by 25.4 percent, 23.9 percent and 14.1 percent. The percentage of working filigree artisans in most of the high school education that is equal to 46.5 percent and the rest junior high school education, elementary and S1 respectively by 33.8 percent, 16.9 percent and 2.8 percent.

Selection of the best model is obtained by comparing the value of the GCV and the value of R^2. GCV value of the smallest and largest value of $R^2$is the best model. Comparisons are made on the various functions of the base amount (BF = 19, 38 and 57), and various maximum interaction (MI = 1, 2 and 3). All possible models that have been tested obtained best model with criteria model that has the smallest value GCV and $R^2$are great. In detail, the selection of the best models are presented in Table 4.

Table 4. The Best Models of Eye Fatigue Based on Complaint Various BF By GCV, R^2

No	BF	MI	MO	GCV	R^2	Prediction Model
1	19	3	3	0.172	0.970	Y = 1.116 + 0.397 BF3 + 0.011 BF4 - 0.011 BF5 + 0.003 BF6 - 0.002 BF9 + 2.01114E-03 BF11 - 0.170 BF12 - 0.046 BF16 BF2 = max(0, 270.000 - I) BF3 = max(0, VR - 101.700) BF4 = max(0, 101.700 - VR) BF5 = (TP = 1 OR TP = 4) BF4 BF6 = (TP = 2 OR TP = 3) BF4 BF8 = max(0, 32.400 - SH) BF2 BF9 = (MK = 2) BF2 BF11 = max(0, JP - 15.000) BF9 BF12 = max(0, FS - 0.920) BF6 BF16 = max(0, U - 34.000) BF2
2	38	3	3	0.156	0.968	Y = 1.090 - 0.405 BF3 + 0.012 BF4 - 0.011 BF5 + 0.003 BF6 + 0.003 BF8 + 2.66101E-03 BF11 + 0.047 BF16 + 5.913 BF25 + 0.573 BF26 BF2 = max(0, I - 270.000) BF3 = max(0, VR - 101.700) BF4 = max(0, 101.700 - VR) BF5 = (TP = 1 OR TP = 2) BF4 BF6 = max(0, 32.400 - SH) BF2 BF9 = (MK = 2) BF2 BF11 = max(0, JP - 15.000) BF9 BF16 = max(0, U - 34.000) BF2 BF25 = max(0, 0.400 - UBK) BF26 = max(0, U - 20.000) BF25
3	57	3	3	0.156	0.968	Y = 1.090 - 0.405 BF3 + 0.012 BF4 - 0.011 BF5 + 0.003 BF6 + 0.003 BF8 + 2.66349E-03 BF11 + 0.047 BF16 + 5.913 BF25 + 0.573 BF26 BF2 = max(0, I - 270.000) BF3 = max(0, VR - 101.700) BF4 = max(0, 101.700 - VR) BF5 = (TP = 1 OR TP = 2) BF4 BF6 = max(0, 32.400 - SH) BF2 BF9 = (MK = 2) BF2 BF11 = max(0, JP - 15.000) BF9 BF16 = max(0, U - 34.000) BF2 BF25 = max(0, 0.400 - UBK) BF26 = max(0, U - 20.000) BF25

Keterangan:
Age (U), Work Period (MJ),Length Work (L),Education Level (TP), Correction Visus (KV), Flicker Before (FS),Room Volume (VR), Size Work Material (UBK), Intensity (I), Glare (S), Temperature (SH), Direction Ray (AS), Wall Color (WD), Visibility (JP), Motif Openwork Color (WK), Makeshift Motif (MK), Makeshift Completion Time (WPK), Glare Cloth (SH),

The best model is obtained on the number BF = 38, MI = 3, and MO = 3 with a value of GCV of 0.156 and R^2 = 0.968.The best models obtained ARS is interpreted on the basis of functionality, and to standardize the variables that do not cause eye fatigue complaints by craftsmen are:

• BF3 = max(0, VR - 101.700)

That is, the coefficient of BF3 would be meaningless if the filigree artisans using the size of the room above 101.7 m^3each increase of one basis function (BF3) can reduce the value of a complaint by 0.405. Or if the filigree artisans using the size of the room above 101.7 $m^3$the complaint will be decreased by (0.405)(1)=0.405, and if the parent base plus the complaint is worth [-0.405+1.090] = 0.685. This means that the complaints value of 0.685 ifin ln(0.685) = -0.378 < 0 then tends eyestrain.

• BF4 = max(0, 101.700 - VR)

That is, the coefficient BF4 be meaningful if the filigree artisans using the size of the room is less than 101.7 m^3each increase of one basis function (BF3) can improve the complaint amounted to 0,012. Or if the filigree artisans using the size of the room is less than 101.7 m^3then keluhaan will increase by [0,012(1)+1.090] Hz = 1.102. This means that the complaints value of 1.102 if in ln(1.102) = 0.097 > 0 then tends eyes are not tired.

• BF5 = (TP = 1 OR TP = 2) max(0, 101.700 - VR)

That is, the coefficient BF5 be meaningful if the filigree artisans with the level of primary and secondary education and have a room size below 101.7 m^3, then each increase of one basis function (BF5) can decrease the complaintsvalue of 0.011. Or if the filigree artisans with the level of primary and secondary education and has the size of the room below the 101.7 m^3complaints decreased by [-0.011(1)(1)+1.090] = 1.079. This means that the complaintsvalue of 1.079 if in ln(1.079) = 0.076 > 0 then tends eyes are not tired.

• BF8 = max(0, 32.400 - SH) max(0, I - 270.000)

That is, the coefficient BF8 be meaningful if the filigree artisans working on using SH below 32.4°C and light intensity of more than 270 lux then each increase of one basis function (BF8) can increase the complaintsvalue of 0.003. Or if the filigree artisans using temperature below 32.4°C and light intensity of more than 270 lux, the complaint will be increased by

[0,003(1)+1.090] Hz = 1.093. This means that the complaintsvalue of 1.093 if in ln(1.093) = 0.087 > 0 then tends eyes are not tired.

• BF9 = (MK = 2) max(0, I - 270.000)

That is, the coefficient BF9 be meaningful when craftsmen openwork motif in the work using two colors of yarn and a light intensity of more than 270 lux then each increase of one basis function (BF9) can increase thecomplaints value of 0.003. Or if the filigree artisans using two colors of yarn motif and light intensity of more than 270 lux, the complaint will be increased by [0,003(1)+1.090] Hz = 1.093. This means that thecomplaints value of 1.093 if in ln(1.093) = 0.087 > 0 then tends eyes are not tired.

• BF11 = max(0, JP-15.000)(MK = 2) max(0, I - 270)

That is, the coefficient BF11 be meaningful if the filigree artisans working using a visibility of more than 15 cm and 2 openwork motif thread colors and light intensity of more than 270 lux then each increase of one basis function (BF11) can increase the complaintsvalue of 0,003. Or if the filigree artisans using the visibility of more than 15 cm and 2 openwork motif thread colors and light intensity of more than 270 lux, the complaint will be increased by [0,003(1)+1.090] Hz = 1.093. This means that thecomplaints value of 1.093 if in ln(1.093) = 0.087 > 0 then tends eyes are not tired.

• BF16 = max(0, U - 34.000)max(0, I - 270)

That is, the coefficient BF16 be meaningful if the filigree craftsmen have over 34 years of age with a light intensity of more than 270 lux then each increase of one basis function (BF16) can decrease the complaints value of 0,047. Or if the filigree artisans have over 34 years of age with a light intensity of more than 270 lux, the complaint will go down by[-0,047(1)+1.090] Hz = 1.043. This means that thecomplaints value of 1.043 if in ln(1.093) = 0.042 > 0 then tends eyes are not tired.

• BF25 = max(0, 0.400 - UBK)

That is, the coefficient BF25 be meaningful if the filigree artisans using working field sizes below 0.4 m^2each increase of one basis function (BF25) can increase the value of the complaint amounted to 3,913. Or if using a filigree artisans working under the field size of 0.4 $m^2$the complaint will rise by [3,913(1)+1.090] Hz = 5.003. This means that thecomplaints value of 5.003 if in ln(5.003) = 1.61 > 0 then tends eyes are not tired.

• BF26 = max(0, U - 20.000) max(0, 0.400 - UBK)

That is, the coefficient BF26 be meaningful if the filigree craftsmen have over 20 years of age and use the size of the work area below 0.4 m^2each increase of one basis function (BF26) can increase the value of the complaint amounted to 0.523. Or if using a filigree artisans working under the field size of 0.4 $m^2$the complaint will rise by [0,523(1)+1.090] Hz = 1.613. This means that thecomplaints value of 1.613 if in ln(1.613) = 0.478 > 0 then tends eyes are not tired.

Table 5. Variables Affecting Foremost in Eye Fatigue Based on Complaints

Variables	Complaints		
	BF=38, MI=3, MO=3 GCV=0.158 R^2 =0.389 (constant = 1.090)		
	Sign	Contribution	Estimator (Knot)
Age (U)	√	71.132	(+0.047) (U+34)(I+270) (+0.523) (U+20)(UBK-0.4)
Work Period (M)	X		
Length Work (L)	X		
Education Level (TP)	√	83.741	(-0.011) (TP=1.2)(VR-101.7)
Visus Before (VS)	X		
Correction Visus (KV)	X		
Flicker Before (FS)	X		
Room Volume (VR)	√	100.00	(-0.405) (VR+101.7) (+0.012) (VR-101.7)
Size Work Material (UBK)	√	58.366	(+3.913) (UBK-0.4)
Intensity (I)	√	60.502	(I+270)
Glare (S)	X		
Temperature (Sh)	√	33.457	+0.003 (Sh-32.4) (I+270)
Direction Ray (AS)	X		
Wall Color (WD)	X		
Visibility (JP)	√	43.805	(+0.0028) (JP+15)(MK=2) (I+270)
Makarawo Color (WK)	X		
Makarawo Motif (MK)	√	50.220	(+0.003) (MK=2) (I+270)
Makarawo Completion Time (WPK)	X		
Glare Cloth (SK)	X		

Ket: √ = significant, X = notsignificant, + above, - below, = right

4. CONCLUSION

Decrease eye fatigue is influenced by the size of the room is less than 101.7 m^3, the temperature below 32.4°C, visibility of more than 15 cm and 2 openwork motif thread colors and light intensity of more than 270 lux.

Eye fatigue complaints by craftsmen influenced by age above 17 years followed intensity of 270 lux, the level of primary and secondary education followed by the volume of the room is less than 101.7 m^3, the work materialsize of approximately 0.4 m^2, light intensity of more than 270 lux, temperature below 32.4°C followed by a light intensity of more than 270 lux, visibility of more than 15 cm, working period of 2 years followed by a light intensity of more than 270 lux.

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