

Arabic Sign Language Recognition

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ABSTRACT

The objective of the research presented in this paper is to facilitate the communication between the deaf and non deaf people. To achieve this goal, computers should be able to visually recognize hand gestures from image input. An efficient and fast algorithm for gestures of manual Arabic letters for the sign language is proposed. The proposed system uses the concept of hand geometry for classifying letter shapes. Experiments revealed that satisfactory results are obtained via the proposed algorithm. The experiment results show that the gesture recognition rate of Arabic alphabet for different signs is 81.6 %

General Terms

Pattern Recognition, Human computer Interaction, Computer Vision.

Keywords

Sign language recognition, image analysis, hand gestures, hand geometry.

1. INTRODUCTION

Normally, there is no problem when two deaf persons communicate using their common sign language. The problem arises when a deaf person wants to communicate with a non-deaf person. Usually both will be unsatisfied in a very short time [1].

Signing has always been part of human communications. For thousands of years, deaf people have created and used signs among themselves. Those signs were the only form of communication available for many deaf people. Within the variety of cultures of deaf people all over the world, signing evolved to form complete languages. Sign language is a form of manual communication and is one of the most natural ways of communication for most people in deaf communities. There has been a surging interest in recognizing human hand gestures.

The aim of the sign language recognition is to provide an accurate and convenient mechanism to transcribe sign gestures into meaningful text or speech so that communication between deaf and hearing society can easily be made.

Sign language is not uniform, but vary from country to country and there effort , research and attempts to unify the sign language of each country separately, such as Egypt, Jordan and Saudi Arabia to help members of the deaf and dumb for each community. [2].

Most of the previous studies on sign languages are based on vision or glove based methods [3]. In the vision based method, the system uses image processing techniques to recognize the gestures without imposing any limitation on the

user. While in the glove based method, the user needs to wear special devices, like gloves or markers, to provide the system with data related to the hand shape and motion [4].

Many researchers have been working on hand gestures in many sign languages. Unlike other sign languages such as the American Sign Language (ASL) [5], the Chinese Sign Language (CSL) [6], the Dutch Sign Language, and the Australian Sign Language (Auslan) [7], the Arabic Sign Language (ArSL) has not received a lot of attention [4].

The research work in [2] presented an automatic translation system for gestures of manual alphabets in the Arabic sign language. it does not rely on using any gloves or visual markings. The extracted features phase depends on two stages, edge detection stage and feature-vector-creation stage. it using minimum distance classifier (MDC) and multilayer perceptron (MLP) classifier to detect the 15 characters only.

The rest of the paper is organized as follows. Section two presents an overview on the hand detection. Section three explains the proposed algorithm. Section four explains experimental results. Section five presents the conclusion and future work

2. Hand detection

The algorithm uses skin detection with a complex background [13]. The algorithm adopts skin color detection as the first step of skin detection. Due to YCbCr color space transform, it is faster than other approaches [14], [15]. The algorithm computes the average luminance Y_{avg} of the input image is given in eqn 1.

$$Y_{avg} = \sum y_{i,j} \quad (1)$$

Where $y_{i,j} = 0.3 R + 0.6 G + 0.1 B$ should be normalized to the range (0, 255), and i, j are the indices of the pixel. According to Y_{avg} , the algorithm can determine the compensated image C_{ij} by the following equations [13]:

$$\begin{aligned} R'_{i,j} &= (R_{i,j})^\tau \\ G'_{i,j} &= (G_{i,j})^\tau \\ C_{i,j} &= \{R'_{i,j}, G'_{i,j}, B_{i,j}\} \end{aligned} \quad (2)$$

Where

$$\tau = \begin{cases} 1.4, & Y_{avg} < 64 \\ 0.6, & Y_{avg} > 192 \\ 1, & \text{otherwise.} \end{cases} \quad (3)$$

Col 4	Col 3	Col 2	Col 1	
14	13	12	11	Row1
24	23	22	21	Row 2
34	33	32	31	Row 3
44	43	42	41	Row 4

Fig. 4: 16 zones Hand shape

Note that the algorithm compensates the color of R and G to reduce computation. Due to chrominance (Cr) which can represent human skin well, the algorithm only consider Cr factor for color space transform to reduce the computation. Cr is defined as follows[13]:

$$Cr = 0.5R' - 0.419G' - 0.081B \quad (4)$$

Accordingly, the human skin can be obtained by a binary matrix as follows:

$$S_{ij} = \begin{cases} 0, & 10 < Cr < 45 \\ 1, & \text{otherwise} \end{cases} \quad (5)$$

Where “0” is the white point and “1” is the black point.

The algorithm implements a filtration by a 5×5 mask. First, the algorithm segments S_{ij} into 5×5 blocks, and calculates how many white points in a block. Then, every point of a 5×5 block is set to white point when the number of white points is greater than half the number of total points. Otherwise, if the number of black points is more than a half, this 5×5 block is modified to a complete black block, as shown in Fig.1 [13].

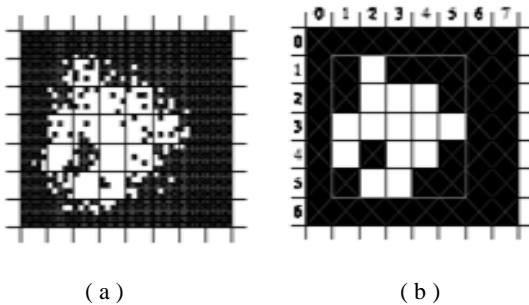


Fig. 1: (a) An example of S_{ij} (b) removes noise by the 5×5 filter.

The algorithm using "regionprops" matlab function to measure a set of properties for each connected component (object) in S_{ij} as {'Area', 'BoundingBox', 'Centroid'}. The algorithm isolates the hand and face as in Fig. 2.

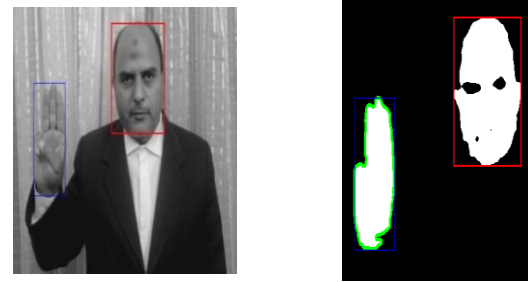


Fig. 2: isolates the hand and face a) gray image b) Blackwhite image with detecting hand contour

Then, the technique in [20] is used to detect the inner circle as shown in Fig. 2. The inner circle represents the palm of the hand.

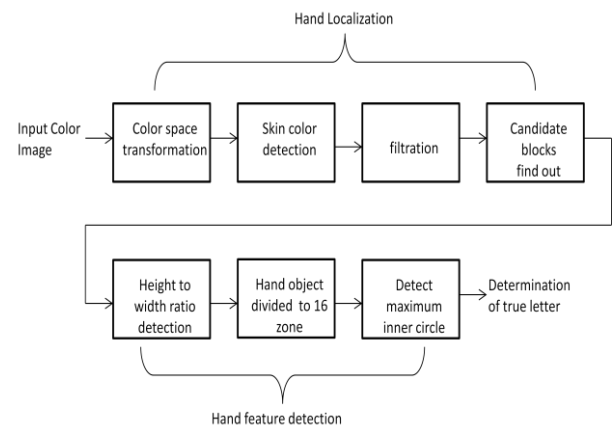


Fig. 3: The flow of proposed method

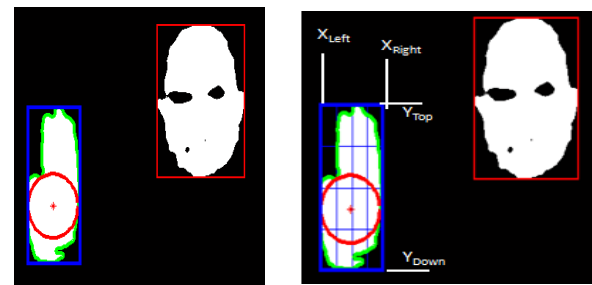


Fig. 5: hand contour detecting and largest inner circle

3. The proposed Algorithm

The proposed algorithm divides the rectangle surrounding by the hand shape in Fig. 5 into 16 zones as in Fig. 4.

The proposed algorithm classifies the Arabic sign language alphabets into four classes. It depends on the inner circle position, as follows.

- A- **Top - Right (T-R) class** in which the inner circle is intersecting with top quarter (Row 1) and right side quarter (Col 1)

- B- **Top - Not Right (T-NR)** class in which the inner circle is intersecting with top quarter (Row 1) and is not intersecting with right side quarter (Col 1)
- C- **Not Top – Right (NT-NR)** class in which the inner circle is not intersecting with top quarter (Row 1) and intersecting with right side quarter (Col 1)
- D- **Not Top – Not Right (NT-NR)** class in which the inner circle is not intersecting with top quarter (Row 1) and is not intersecting with right side quarter (Col 1)

Fig. 6 represents the four classes of the arabic letters.

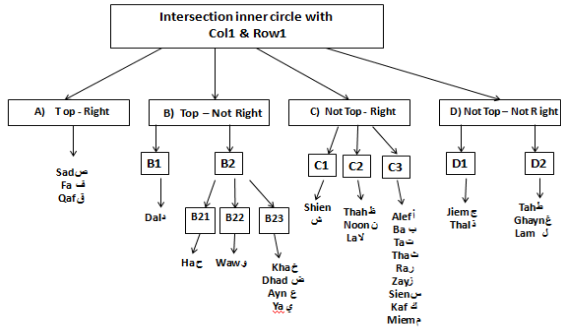


Fig. 6: The classification of letters

3.1. Top-Right (T-R) class

In this class, the inner circle is intersecting with the top and right side quarters. It is obvious from Fig. 7 that the three letters {Sad ص, Fa ف, Qaf ق} the hand palm is closed. Consequently, the inner circle is covering the all sixteen zones including the top and right quarters. In this research work, discrimination of this class can be achieved by computing the centroid of white pixel only in the top quarter and / or the right quarter. However, in order to reduce the computation time, the centroid of top quarter only will be computed, as shown the following algorithm.

Sad ص Fa ف Qaf ق

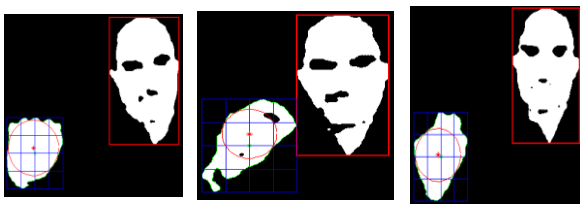


Fig. 7: T - R Letters

Top - Right (T - R) class

Step 1: Compute the centroid of white pixels in Row 1 for each individual character using the following equation:

$$X_c \leftarrow \frac{1}{N} \left[\sum_{y=Y_{Top}}^{Y_{Top} + H/4} \sum_{x=X_{Left}}^{X_{Right}} x \quad \text{if } f(x,y) = 1 \right] \quad (6)$$

$$Y_c \leftarrow \frac{1}{N} \left[\sum_{y=Y_{Top}}^{Y_{Top} + H/4} \sum_{x=X_{Left}}^{X_{Right}} y \quad \text{if } f(x,y) = 1 \right]$$

where, H is the height of the image, N is the number of white pixels, and $f(x,y)$ denotes the value of pixel {1 for white pixel and zero for black pixel}

Step 2: Compute the scaled value of X_c and Y_c

$$H_{Ratio} \leftarrow 100$$

$$W_{Ratio} \leftarrow H_{Ratio} * W/H$$

$$X_{CR} \leftarrow (X_c - X_{Left}) * W_{Ratio} / H_{Ratio} \quad (7)$$

$$Y_{CR} \leftarrow (Y_c - Y_{Top}) * W_{Ratio} / H_{Ratio}$$

Where, W is the width of the image

Compute the average value \bar{X}_{CR} , \bar{Y}_{CR} using:

Step 3:

$$\bar{X}_{CR} \leftarrow \frac{1}{m} \sum_{i=1}^m X_{CR_i} \quad (8)$$

$$\bar{Y}_{CR} \leftarrow \frac{1}{m} \sum_{i=1}^m Y_{CR_i}$$

Where m is the number of images of each character.

3.2. Top - Not Right (T-NR) class

In this class, the inner circle is intersecting with the top and not intersecting with right side quarters. It is obvious from Fig. 8 that the seven letters {Ha ح, Kha خ, Dal د, Dhad ض, Ayn ع, Waw و, Ya ي}. Consequently, the inner circle is not covering the all right quarters. In this paper, discrimination of this class can be achieved as shown the following algorithm.

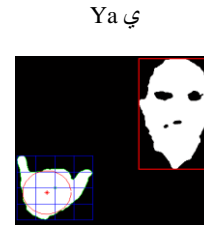
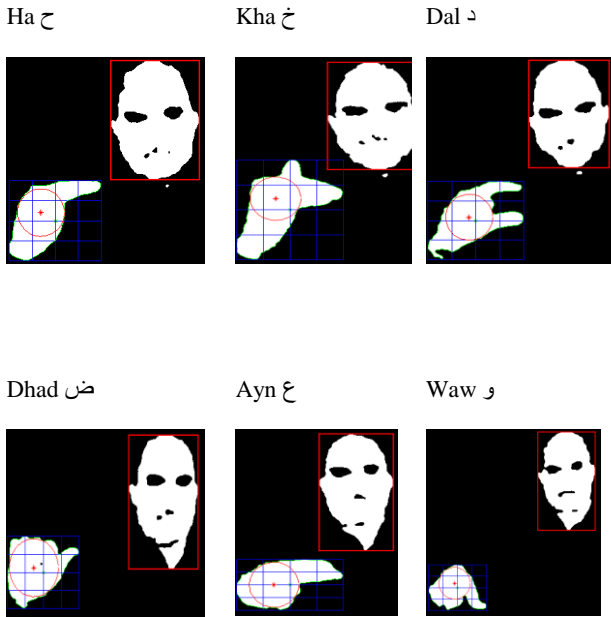


Fig.8: T - NR Letters

Top - Not Right (T - NR) Class

Step1: Classifying the letters by counting the number of objects in Col 1

Classifier B1: Letter Dal (د) has only two objects in the right side (Col 1)

Classifier B2: Letters {Ha ح , Kha خ , Dhad ض , Ayn ع , Waw و , Ya ي } are one object in the right (Col 1)

Classifier B21: if zones 21,31 and 41 have not white pixels, So the letter is (Ha ح)

Classifier B22: if zone 41 have white pixels, So the letter is (Waw و)

Classifier B23: if not C21 and C22 then compute the centroid of the three characters {Kha خ , Dhad ض , Ayn ع , Ya ي } using the following equation:

$$X_c \leftarrow \frac{1}{N} \left[\sum_{y=y_{Top}}^{y_{Down}} \sum_{x=X_{Right}-\frac{W}{4}}^{X_{Right}} x \quad \text{if } f(x,y) = 1 \right] \quad (9)$$

$$Y_c \leftarrow \frac{1}{N} \left[\sum_{y=y_{Top}}^{y_{Down}} \sum_{x=X_{Right}-\frac{W}{4}}^{X_{Right}} y \quad \text{if } f(x,y) = 1 \right]$$

Step2: Then Compute the average value $\overline{X_{CR}}, \overline{Y_{CR}}$ using equations (7, 8)

3.3. Not Top – Right (NT- R) class

In this class, the inner circle is not intersecting with the top and intersecting with right side quarters. It is

obvious from Fig. 9 that The thirteen letters {Alef أ , Ba ب , Ta ت , Tha ث , Ra ر , Zay ز , Sien س , Shien ش , Thah ظ , Kaf ك ,Miem م ,Noon ن , La لا }.

Consequently, the inner circle is not covering the all top

quarters. In this paper, discrimination of this class can be achieved as shown the following algorithm.

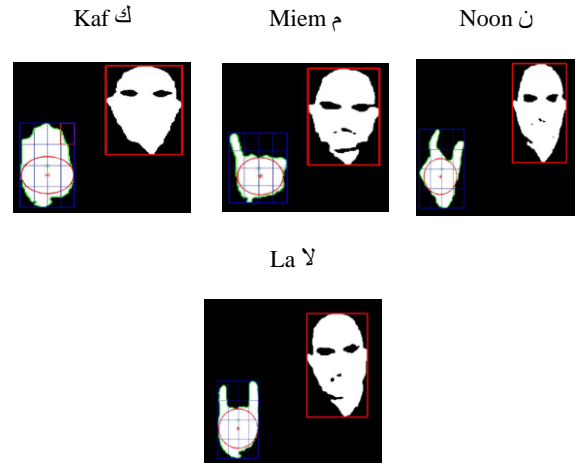
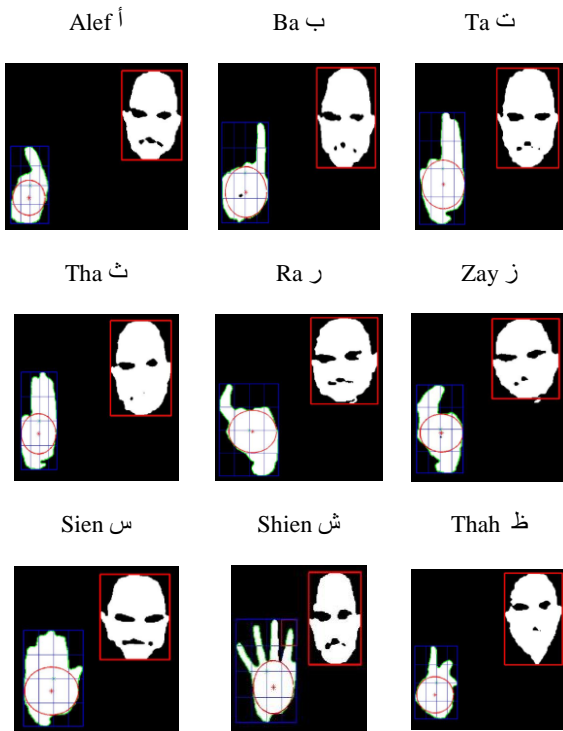


Fig. 9: NT - R Letters

Top Not Right (TNR) Class

Classifying the letters by number of sub object in Row 1

Classifier C1: Letters {Shien ش} is more than two sub objects in the top (Row1)

Classifier C2: - Letters {Thah ظ , Noon ن , La ل} have tow objects in the top side (Row1). Compute the centroid of white pixels in Row 1 for each sub object using the following equation:

$$\begin{aligned}
 X_{c_{RSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{Top}}^{y_{Top}+H/4} \sum_{x=X_{RSO_Left}}^{X_{RSO_Right}} x \text{ if } f(x,y) = 1 \right] \\
 Y_{c_{RSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{Top}}^{y_{Top}+H/4} \sum_{x=X_{RSO_Left}}^{X_{RSO_Right}} y \text{ if } f(x,y) = 1 \right] \\
 X_{c_{LSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{Top}}^{y_{Top}+H/4} \sum_{x=X_{LSO_Left}}^{X_{LSO_Right}} x \text{ if } f(x,y) = 1 \right] \\
 Y_{c_{LSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{Top}}^{y_{Top}+H/4} \sum_{x=X_{LSO_Left}}^{X_{LSO_Right}} y \text{ if } f(x,y) = 1 \right]
 \end{aligned} \tag{9}$$

- Where :
- RSO is Right Sub Object
 - LSO is Left Sub Object

Then Compute the average value as using the equations (7, 8)

Classifier C3: Letters {Alef أ , Ba ب , Ta ت , Tha ث , Ra ر , Zay ز , Sien س , Kaf ك ,Miem م } have one object in the Top (Row1), then using the equations (6, 7, and 8)

3.4. Not Top- Not Right (NT-NR) class

In this class, the inner circle is not intersecting with the top and not intersecting with right side quarters. It is obvious from Fig. 10 The only five letters {Jiem ج , Thal ذ , Tah ط , Ghayn غ , Lam ل }. Consequently, the inner circle is not covering the all top and right quarters. In this paper, discrimination of this class can be achieved as shown the following algorithm.

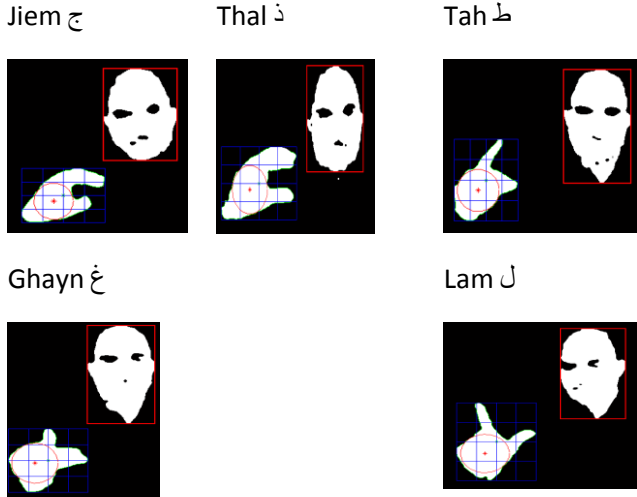


Fig. 10: T R Letters

Not Top – Not Right (NT - NR) Class

Classifying the letters by number of sub objects in Col 1

Classifier D1:

Letters {Jiem ج , Thal ذ } have two sub objects in the right side (Col 1). Compute the centroid of white pixels in Col1 for each sub object using the following equation:

$$\begin{aligned}
 X_{c_{TSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{TSO_Down}}^{y_{TSO_Top}} \sum_{x=x_{Right}-W/4}^{x_{Right}} x \text{ if } f(x,y) = 1 \right] \\
 Y_{c_{TSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{TSO_Down}}^{y_{TSO_Top}} \sum_{x=x_{Right}-W/4}^{x_{Right}} y \text{ if } f(x,y) = 1 \right] \\
 X_{c_{DSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{DSO_Down}}^{y_{DSO_Top}} \sum_{x=x_{Right}-W/4}^{x_{Right}} x \text{ if } f(x,y) = 1 \right] \\
 Y_{c_{DSO}} &\leftarrow \frac{1}{N} \left[\sum_{y=y_{DSO_Down}}^{y_{DSO_Top}} \sum_{x=x_{Right}-W/4}^{x_{Right}} y \text{ if } f(x,y) = 1 \right]
 \end{aligned} \tag{10}$$

Where :

- TSO is Top Sub Object
 - DSO is Down Sub Object
- Then Compute the average value as using the equations (7, 8)

Classifier D2:

Letters {Tah ط , Ghayn غ , Lam ل , Ya ي } have one sub object in the right side (Col1), then using the equations (9, 7, and 8)

5. EXPERIMENTAL

To evaluate the performance of the proposed system, several images containing Arabic letters have been classified. Several experiments have been conducted. Detecting sub object centroid of each object in top (Row 1) and right (Col 1) depends on the inner circle classifier. Due to the unavailability of a dataset for gestures from Arabic sign language, we had to build our own gestures database. The results as shown in table 1.

6. CONCLUSION AND FUTURE WORK

In this paper, a system for the purpose of the recognition and translation of the Arabic letters is designed. The proposed system depends on the inner circle position. The extracted features are scale invariant, which make the system more flexible. Experiments revealed that the proposed system was able to recognize Arabic letters based on the hand geometry.

There is still a lot of further research works in performance improvement considering different descriptors and classifiers. Moreover, additional improvements can be applied for this system to be used for mobile applications to provide easy communication way among deaf people as well as blind and deaf people.

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Table 1:Expermental results For arabic alphabets

	ا	ب	ت	ث	ج	ح	خ	د	ذ	ر	ز	س	ش	ص	ض	ط	ظ	ع	غ	ف	ق	ك	ل	م	ن	و	ي	لا	%
Alef	51	0	43	0	0	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	51
Ba3	0	9	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	97
Ta3	40	0	45	2	0	0	0	0	0	0	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	45
Tha3	0	0	2	68	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	68
Geem	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Ha3	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Kha3	0	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Dal	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Thal	0	0	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	81.
Ra3	7	2	2	0	0	0	0	0	0	47	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	47
Zay	6	0	13	2	0	0	0	0	0	20	47	11	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	47
Seen	2	0	2	27	0	0	0	0	0	0	3	52	0	0	0	0	0	0	0	0	0	14	0	0	0	0	0	0	52
Sheen	0	0	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Sad	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	21	7	0	0	0	0	0	0	0	56.
Dad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Da3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	10
Thaa3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	93	0	0	0	0	0	0	0	0	0	0	2	76.
Aien	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	144	0	0	0	0	0	0	0	0	0	0	10
Ghain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	10
fa3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	10
Kaaf	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	10	0	0	0	0	0	0	0	62.
Kaf	0	0	0	22	0	0	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0	65	0	0	0	0	0	0	65
Laam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	14	0	0	0	0	0	87.
Mee	0	2	0	0	0	0	0	0	0	14	8	0	0	0	0	0	0	0	0	0	0	0	0	76	0	0	0	0	76

