

For classification, first calculate the arithmetic average of the positive, negative and neutral scores of each word synsets of the tweet by summing up the different scores of each synset class and dividing by the total number of synsets, see equation (1):

$$\begin{aligned} \text{Score pos (W)} &= \frac{1}{n} \sum_{i=1}^n \text{score pos (Si)} \\ \text{Score neg (W)} &= \frac{1}{n} \sum_{i=1}^n \text{score neg (Si)} \\ \text{Score neu (W)} &= \frac{1}{n} \sum_{i=1}^n \text{score neu (Si)} \end{aligned} \quad (1)$$

Where S is the score of synset i, for word, and n is the number of synsets of word, where W is a word that belongs to a set of words.

The second step in classification is determined by the sentiment scores of the tweet by averaging each word score in T, where it represents a single tweet from the set of tweets; see equation (2):

$$\begin{aligned} \text{Total Score pos (T)} &= \frac{1}{n} \sum_{i=1}^n \text{score pos (Wi)} \\ \text{Total Score neg (T)} &= \frac{1}{n} \sum_{i=1}^n \text{score neg (Wi)} \\ \text{Total Score neu (T)} &= \frac{1}{n} \sum_{i=1}^n \text{score neu (Wi)} \end{aligned} \quad (2)$$

4.1 In Formula (1) [13],[23]

The class of the tweet corresponds to the greatest positive, negative, and neutral score:

$$\text{Sentiment} = \begin{cases} \text{Positive tweet if } \text{TotalScore pos (T)} > \text{TotalScore neg (T)} \\ \text{Negative tweet if } \text{TotalScore pos (T)} < \text{TotalScore neg (T)} \\ \text{Neutral tweet if } \text{TotalScore pos (T)} = \text{TotalScore neg (T)} \end{cases}$$

4.2 In Formula (2) [17],[19],[26],[9],[22],[11]

The difference of the total positive and negative scores of the tweet represents its overall sentiment score. In addition, the overall score will be in the range (-1, 1) where a value greater than zero denotes a positive sentiment, and a value less than zero denotes a negative sentiment. Otherwise, the tweet is neutral.

$$\text{Total Score} = \text{Total Score pos (T)} - \text{Total Score neg (T)}$$

$$\text{Sentiment} = \begin{cases} \text{Positive if } \text{Total Score} > 0 \\ \text{Negative if } \text{Total Score} < 0 \\ \text{Neutral if } \text{Total Score} = 0 \end{cases}$$

4.3 Proposed technique to use Arabic SWN lexicon in Arabic tweet

To improve the efficiency of using SentiWordNet in sentiment classification for Arabic tweets, we propose a technique that consists of two phases:

(1) SentiWordNet Interpretation Phase

As previously mentioned, each word in SentiWordNet lexicon can have multiple synsets. Therefore, to assign the positive, negative and neutral scores to each word in the text, we need to be performing word synset disambiguation. Initially we removed the unnecessary words from each tweet. Then, we had to import the Arabic Sentiment lexicon (ArSenL) as an MS excel sheet; after that, we looked up each word to check if it belonged to the list of Arabic negation words; if true,

the sentiment score was assigned as negative (Scoreneg= 1; Scorepos= 0; Scoreneu = 0). If not, we searched it in ArSenL; if we found it there, we would take all possible synsets scores that are relevant with the POS of the word. If we did not find it, the word would be stemmed by ISRI and then we searched for it again in the ArSenL; also if we did not find it in the lexicon, we would stem the word by Light Stemmer as a second option to find the word in the lexicon. Finally, if the word was not found there either, we would assign a zero value to all scores.

Algorithm 1 : Word Score Summation

```

if WordAveragPositive >= 0 then
  TotalWord= WordAveragPositive - WordAveragNegative
  if TotalWord > 0 then
    | TotalPositiveScor+= WordAveragPositive
  end
  else if TotalWord < 0 then
    | TotalNegativeScor+= WordAveragNegative
  end
  else
    | TotalNeutralScor+= WordAveragNeutral
  end
end
if WordAveragPositive == 0 then
  TotalWord= WordAveragNeutral - WordAveragNegative
  if TotalWord >= 0 then
    | TotalNeutralScor+= WordAveragNeutral
  end
  else if TotalWord < 0 then
    | TotalNegativeScor+= WordAveragNegative
  end
end
end

```

Figure 4. Algorithm1.

(2) Sentiment Calculations Phase

In this phase, we apply two calculation methods on tweets to classify them as positive, negative or neutral using word scores obtained from the first phase.

Word score summation method: In this method, we applied Algorithm (1) where summation is the positive, negative and neutral scores for each word in a tweet then calculated the average of each category's scores in each word using Equations (2). Then, to determine the sentiment of the word we followed Formula 2, where we took only the result score in the second step and ignored the other score. To classify each word, we had to calculate the total result of each class (positive, negative and neutral) score. Before applying Algorithm (2) we only considered the result of each word to calculate the total result of the tweet and ignored the other scores.

Tweet score summation method: In this method, we summarize all the positive, negative and neutral scores obtained from the first step. We applied Algorithm (2) to solve the neutral classification issue; we implemented a condition that if the total positive score equals or is more than 0.25, then we performed Formula 2; if not, we implemented another condition, which is: if the difference of the total negative score and the total neutral score is less than zero if the total negative score is more 0.25, then the sentiment of the

tweet is negative. Since all words in the SentiWordNet lexicon have three values (positive, negative and neutral), most of the words have low positive and negative scores and high neutral scores. So, we applied these thresholds to reduce the neutral results.

4.4 Evaluation Measures

In order to decide whether the classifiers were accurately capturing a pattern, we evaluated the model. Furthermore, confusion matrices, precision, recall, F-measure and accuracy methods were used for evaluating the proposed classifiers performance and comparing them with each other.

Algorithm 2 : Tweet Score Summation

```

if TotalPositiveScore >= 0.25 then
  TotalTweet=TotalPositiveScore-TotalNegativeScore
  if TotalTweet > 0 then
    | Print Tweet is Positive
  end
  else if TotalTweet < 0 then
    | Print Tweet is Negative
  end
  else
    | Print Tweet is Neutral
  end
end
else
  TotalTweet=TotalNeutralScore-TotalNegativeScore
  if TotalTweet < 0 Or TotalNegativeScore >= 0.25 then
    | Print Tweet is Negative
  end
  else if TotalTweet < 0 then
    | Print Tweet is Neutral
  end
end
end

```

Figure 5. Algorithm 2.

5. Results And Discussion

In this section, we evaluate our semantic approach in a Twitter Arabic sentiment analysis by two experiments performed on Arabic tweets: In the first experiment, we used the Arabic Sentiment Lexicon (ArSneL) and in the second, we used the English SentiWordNet. In addition, we presented the results of different experiments by observing the performance of each classifier to obtain the best one for Arabic sentiment analysis. Also, we measured the effectiveness of both sentiment lexicons: Arabic and English.

5.1 Experiment 1

In this experiment, we studied the performance of using the Arabic Sentiment Lexicon (ArSneL) classifier in an Arabic sentiment analysis of Twitter. Also, we tested the effect of preprocessing on the ArSneL classifiers performance, as well as the effect of using Arabic stemming tools, the Arabic NLP Stanford POS tagging tool and negation on the performance. We divided this experiment into four classifiers.

In classifier (1), we used an unlabeled Arabic tweet dataset that consists of 2,000 tweets, which we collected before the first experiment and which were

cleaned of noisy Twitter symbols and duplicated tweets. We applied both formulas (1 and 2) and used ArSenL on the unlabeled Arabic tweets dataset that consists of 2,000 tweets, and which was cleaned of noisy Twitter symbols and duplicated tweets. In addition, classifier (2) was applied to the same dataset in classifier (1) but using the proposed technique. In classifier (3), we applied different preprocessing steps to this dataset, such as tokenization, spelling correction and the removal of all punctuation, Arabic stop words, tashkeel, and proper nouns, but there was little impact on the results of the classification. According to the structure of SentiWordNet, part of speech (POS) is considered an important attribute. Therefore, we used POS tagging as a feature in the classifier (4) by using the Arabic NLP Stanford POS Tagging tool. We also used ISRI and Light stemming, as well as handling negation. We applied these features because they may support and accelerate the process of extracting words from the ArSneL lexicon. After extracting scores for each word, we applied our proposed technique for the sentiment classification of Arabic tweets into one of three classes: positive, negative or neutral. All these steps were implemented using Python.

For the evaluation of this experiment, we compared the results of classifying the labeled dataset that we used in the previous experiments by four performance measures: confusion matrices, precision, recall, F-measure and accuracy.

In the first experiment, as shown in Table 2, we applied Formula (1) and (2) and used ArSenL to achieve an accuracy of 41 %, with high precision in the positive class of 72.91 %, but less than reasonable in the neutral class at 2.18 %. Also, in the second classifier we classified the same dataset but used the proposed technique to reduce the neutral result, where the performance accuracy improved, at 42.75 % with the logical distribution of the precision, recall and F-measure percentages.

With regards to improving the performance of the second classifier, we applied different preprocessing steps to the third classifier. However, there was very little improvement in the result of 0.40 %, but, on the other hand, the process was accelerated. Some issues led to this result, which we will explain in detail: We aimed to remove the stop words from the list because some words may cause confusion in classification. For example, ("الذي" - Who) and ("أنا" - I) are stop words that have neutral weight equaling 1 in Arabic and do not add any sentiment to the tweet, so we kept them on the stop words list, but all negation words were removed from the list such as ("لا" and "لم" - No).

Table 1. The synsets of word "من" in ArSneL lexicon.

POS	Positive	Negative	Objective	English Equivalent
V	0.125	0	0.875	yield, grant, concede, allot, accord, award
V	0	0	1	grant, deed_over, confer, bestow, yield, concede, cede, give
V	0.50	0.25	0.25	lend, impart, contribute, bring, bestow, add
N	0.125	0	0.875	favour, favor
N	0	0	1	party_favour, party_favor, favour, favor, thanksgiving, grace, blessing, state_of_grace, saving_grace
N	0.778	0.222	0	grace, goodwill, good_will
N	0.50	0	0.50	grace_of_god, grace, free_grace, seemliness, favour, favor

Table 2. The results of Arabic tweets sentiment analysis classifier.

Arabic Sentiment Lexicon		Confusion matrices			Results			Accuracy
		Positive	Negative	Neutral	Precision	Recall	F-measure	
Formula (1-2)	Positive	463	323	426	72.91 %	31.48 %	43.97 %	41.00 %
	Negative	136	342	248	50.59 %	28.79 %	36.70 %	
	Neutral	36	11	15	2.18 %	2.88 %	2.48 %	
Proposed Technique	Positive	227	111	187	35.75 %	23.55 %	28.39 %	42.75 %
	Negative	108	247	121	36.54 %	25.65 %	30.14 %	
	Neutral	300	318	381	55.30 %	31.28 %	39.96 %	
Preprocessing	Positive	381	269	302	60.00 %	30.14 %	40.13 %	43.15 %
	Negative	74	228	133	33.73 %	24.86 %	28.63 %	
	Neutral	180	179	254	36.87 %	26.57 %	30.88 %	
POS	Positive	376	233	310	59.21 %	29.79 %	39.64 %	42.75 %
	Negative	64	196	96	28.99 %	22.76 %	25.50 %	
	Neutral	195	247	283	41.07 %	27.69 %	33.08 %	

Table 3. The results of translated Arabic tweets sentiment analysis classifier.

English SentiWordNet		Confusion matrices			Results			Accuracy
		Positive	Negative	Neutral	Precision	Recall	F-measure	
Without Preprocessing	Positive	445	254	371	70.08 %	23.07 %	34.71 %	45.60 %
	Negative	65	257	108	38.02 %	27.75 %	32.08 %	
	Neutral	125	165	210	30.48 %	25.64 %	27.85 %	
Preprocessing	Positive	312	204	217	49.13 %	27.88 %	35.58 %	43.50 %
	Negative	51	160	74	23.67 %	20.67 %	22.07 %	
	Neutral	272	312	398	57.76 %	32.17 %	41.33 %	
POS	Positive	448	275	363	70.55 %	32.18 %	44.20 %	43.45 %
	Negative	48	178	83	26.33 %	21.95 %	23.94 %	
	Neutral	139	223	243	35.27 %	26.19 %	30.06 %	

There are other words we could not remove such as ("من"- Mn), which in most Arabic tweets means from or who. On the other hand, the word ("من"- Mn) could mean grant or favor or dead_over, but when it is written with tashkeel "مَنْ", it is different from "مَن", where the former means grant and the latter means who. In Table 1, the ArSenL lexicon has different synsets for the word "من" with the total scores being positive = 3.528, negative = 0.597, neutral = 5.875. However, before removing any stop words, we must remove the tashkeel from the words to avoid these problems. Another issue is misspellings. While a small

percentage of tweets are correct and do not include any misspelled words, most mistakes are made in vowel letters; for example "نتهمه" should be "نتهمه" with (ha' alddamir - هاء الضمير) not (alтта' almarbuta- التاء المربوطة), the other word "إستعماري", should not include hamzah "استعماري", in the word "اوربا" the "و" should be included to be "اوروبا", and the word "اليونانيين" should be written as plural (Greek), but with the "ي" letter included at the end to be "اليونانيين". However, all these words and those like them must be preprocessed regarding spelling correction and stemming before classification.

Means	Tweet
From	يارب توفى الحب و يرجع من طهران بثلاث نقاط و صداه
	Oh God, help my lover (Alhilal FC) and back from Tehran with three points and be the best
Who	من لم يتقن فن الصمت لن يتقن فن الكلام
	Those who have not mastered in silent skill will not mastering in speech skill

Figure 6. Word "من" examples.

In the POS classifier, we added the POS tagging feature to our Arabic sentiment classification. We expected POS would play a major role in sentiment analysis because it is an important attribute in sentiment lexicons. However when using POS tagging, there have not been any noticeable improvements in the performance results of the Arabic SWN classifier at almost 42.75%, aside from accelerating the search process.

On the other hand, we also applied the stemming feature in the POS classifier, including both the Arabic stemmer methods ISRI and Light sequentially; as we explained, the previous ISRI method relies on extracting the root of the word by looking it up in a root dictionary. Therefore, we applied the first step, and if the root of the word was not found, the classifier would go to the next step, Light stemming. This technique allowed us to take advantage of both methods, which may provide a greater possibility of finding a word in the ArSenL lexicon. ISRI Arabic stemming is generally a good method, but it requires updating and a better review of roots because there are many mistakes; for example, if we stemmed the word "بارضنا" meaning our land, it becomes "برض" and this is incorrect. However, if we apply our technique it will not solve the problem because the word "برض" has a score in the ArSenL lexicon.

5.2 Experiment 2

In this experiment, we followed the same steps as in the first experiment, but we used English tweets and English SentiWordNet. Initially, we translated all the Arabic tweets dataset to English using Google Translator API. The total number of tweets we translated was 2,000 Arabic tweets; however we translated twice: the first time without preprocessing and the second after preprocessing. In Table 3, it is clear that when we classified the translated tweets without any preprocessing, the classifier works well, producing fewer classification errors with an accuracy of 45.60%, but in the second classifier after preprocessing the accuracy was 43.50%. In the third classifier, we applied the English POS tagging feature on the translated tweets; after preprocessing we noticed no improvement in accuracy as a whole, but the

Positive precision clearly improved with 21.42% from the first classifier.

Furthermore, this experiment revealed a number of issues that led to an incorrect translation of the Arabic tweets, and in addition, the classifier was not able to manage this:

One of these issues was that some words, such as "كوباني" were translated to be "Kobânî", contained non-English letters such as (â, è, î, ü), so English SWN does not contain words with these letters.

Also there were many misspelled words in the Arabic tweets, as previously mentioned, which is a problem that continued to be one reason for incorrect translations, for example in this tweet "اقسم بالله ان اهل", the word "كللهم", which mean "All" is incorrect, so when we translate, it becomes "swear god people kllahm honest". Another issue was that some derivative words could not be translated by Google (see Figure 7).

Ar	أعشق قراءة تغريداتها كل يوم حتى و أن لم أتبعها فكل تغريدة تكتبها لها ذكرى بداخل
En	Adore reading n_gredatha otabaha every tweet tkptha memory inside

Figure 7. Google translate examples.

With regard to this issue, the tweet in Figure 7 contains the word "تغريداتها"-"her tweets", derived from the word "تغريدة" - "tweets", which Google failed to translate, and also there is the misspelled word, "تكتبها"; the correct word should be "تكتبها" - "Writes it". All these words were neglected by the classifier, which contributed to the low result. Thus, the correct translation for this tweet if there were no misspellings is "I love to read her tweets every day, even if I do not follow her. Any tweet she writes has a memory inside me".

Another issue that appeared in this experiment was with homonyms, which are a group of words that share the same spelling but that have different meanings such as "like" (similar or comparable) and "like" (agreeable or enjoyable). Furthermore, the classifier could not distinguish between the meanings of words, so we had to overcome this issue by translating each Arabic word individually. For example, the translation of the sentence "أنا أحب التفاح" becomes "I like apple"; however, the same sentence translated manually is, "I love apple".

Arabic sentence	أنا أحب التفاح		
Translate sentence	I like apple		
Separate words of sentence	التفاح	أحب	أنا
Translate each word	Apple	Love	I

Figure 8. Homonym example.

By using the first method, the sentiment classifier classified words "like" to neutral with total scores of scorepos=2, scoreneg=0 and scoreneu=3; however, when classifying the word "love", it was positive with total scores of scorepos=2.5, scoreneg= 0.125 and scoreneu=1.375.

5.3 Comparison

Table 4. Accuracy of sentiment analysis systems on BBN datasets.

System	Lexicon	Accuracy
Our system	Arabic SentiWordNet	60,25%
SMK system [6]	Arabic Hashtag Lexicon(dialectal)	63.89%

We tested our system on the existing BBN Blog Posts Sentiment dataset⁴. Table 4 shows the results of ten-fold cross-validation experiments on the dataset, where the results shown for systems have to identify one of three classes: positive, negative, or neutral. The accuracy of our system is convergent to previously published results by Salameh et al. system [6], where they obtained an accuracy of 63.89%.

6. Conclusion And Future Work

In this paper, we explored a new model of Arabic tweets sentiment analysis using a semantic approach, and the effect of different techniques of text preprocessing on the classifications accuracy. The main contribution of this paper is the implementation of a novel Arabic tweets sentiment analysis system by using both Arabic and English sentiment lexicons. With regard to the results, it is clear there are no noticeable effects on performance when applying preprocessing and the POS tagging feature. This is because there are a lot of misspellings and dialect words in Arabic tweets. Moreover, most of the good text preprocessing tools do not support the Python programming language. Furthermore, the stemmer tools produced an incorrect root or a root without meaning. Hence, we conclude that there are two tools that must be improved to support and improve any Arabic natural learning process system. The first is the Arabic spelling correction tools, which need to be developed and more words added. The second is the Arabic stemmer tools that need to include more roots in order to support the searching process.

References

- [1] S. M. Oraby, Y. El-Sonbaty, and M. A. El-Nasr, Exploring the Effects of Word Roots for Arabic Sentiment Analysis, in *Proceedings of the International Joint Conference on Natural Language Processing*. Nagoya, Japan, pp.471-479, 2013.
- [2] J. O'Mahony, Twitter users 'can't spell' Telegraph, <http://www.telegraph.co.uk/technology/twitter/10086819/Twitter-users-cant-spell.html>, December 2015.
- [3] G. Wang, J. Sun, J. Ma, K. Xu, and J. Gu, Sentiment classification: The contribution of ensemble learning, in *Decision support systems*, pp.77-93, 2014.
- [4] A. Agarwal, B. Xie, I. Vovsha, O. Rambow, and R. Passonneau, Sentiment analysis of twitter data, in *Proceedings of the Workshop on Languages in Social Media*, pp.30-38, 2011.
- [5] S. Asur, and B. Huberman, Predicting the future with social media, in *Web Intelligence and Intelligent Agent Technology (WI-IAT)*, pp.492-499, 2010.
- [6] M. Salameh, S. M. Mohammad, and S. Kiritchenko, Sentiment After Translation: A Case-Study on Arabic Social Media Posts, in *Proceedings of the North American Chapter of the Association for Computational Linguistics (NAACL-2015)*, 2015.
- [7] Y. Yu, and X. Wang, World Cup 2014 in the Twitter World: A big data analysis of sentiments in US sports fans' tweets, *Computers in Human Behavior*, pp.392-400, 2015.
- [8] A. R. Hedar, and M. M. Doss, Mining Social Networks' Arabic Slang Comments, in *Proceedings of IADIS European Conference on Data Mining (ECDM'13)*. Prague, Czech Republic, 2013.
- [9] K. Denecke, Using sentiwordnet for multilingual sentiment analysis, in *Data Engineering Workshop, ICDEW 2008, IEEE 24th International Conference*, pp.507-512, 2008.
- [10] M. Anjaria, and R. M. R. Guddeti, A novel sentiment analysis of social networks using supervised learning, *Social Network Analysis and Mining*, vol.4, no.1, pp.1-15, 2014.
- [11] A. Montejo-Ráez, E. Martínez-Cámara, M. T. Martín-Valdivia, and L. A. Ureña-López, Ranked wordnet graph for sentiment polarity classification in twitter, *Computer Speech & Language*, vol.28, no.1, pp. 93-107, 2014.
- [12] K. Denecke, Are SentiWordNet scores suited for multi-domain sentiment classification?, in

⁴ <http://saifmohammad.com/WebPages/ArabicSA.html>

- Digital Information Management, ICDIM 2009, Fourth International Conference*, pp.1-6, 2009.
- [13] M. Guerini, L. Gatti, and M. Turchi, Sentiment analysis: How to derive prior polarities from SentiWordNet, The arXiv, pp.1309-5843, 2013.
- [14] G. Badaro, R. Baly, H. Hajj, N. Habash, and W. El-Hajj, A large scale Arabic sentiment lexicon for Arabic opinion mining, *ANLP 2014*, 2014.
- [15] A. Shoukry, and A. Rafea, Sentence-level Arabic sentiment analysis, in *Proceedings in International Conference of the Collaboration Technologies and Systems (CTS)*, pp.546-550, 2012.
- [16] S. Khoja, APT: Arabic part-of-speech tagger, in *Proceedings of the Student Workshop at NAACL*, pp.20-25, 2001.
- [17] E. Martínez-Cámara, S. M. Jiménez-Zafra, M. T. Martín-Valdivia, and L. A. Urena-López, SINAI: Voting System for Twitter Sentiment Analysis, *SemEval 2014*, 572, 2014.
- [18] A. Hamouda, and M. Rohaim, Reviews classification using sentiwordnet lexicon, In *World Congress on Computer Science and Information Technology*, 2011.
- [19] F. H. Khan, S. Bashir, and U. Qamar, TOM: Twitter opinion mining framework using hybrid classification scheme, *Decision Support Systems*, pp.245-257, 2014.
- [20] E. Refaee, and V. Rieser, Evaluating Distant Supervision for Subjectivity and Sentiment Analysis on Arabic Twitter Feeds, *ANLP 2014*, 2014.
- [21] N. El-Makky, K. Nagi, A. El-Ebshihy, E. Apady, O. Hafez, S. Mostafa, and S. Ibrahim, Sentiment Analysis of Colloquial Arabic Tweets, 2015.
- [22] M. Abdalkader, Sentiment Analysis of Egyptian Arabic in Social Media, 2014.
- [23] R. Ortega, A. Fonseca, M. Mendoza, and Y. Gutierrez, SSA-UO: unsupervised Twitter sentiment analysis, in *Second Joint Conference on Lexicon and Computational Semantics*, vol.2, pp.501-507, 2013.
- [24] A. Mourad, and K. Darwish, Subjectivity and sentiment analysis of modern standard Arabic and Arabic microblogs, in *Proceedings of the 4th Workshop on Computational Approaches to Subjectivity, Sentiment and Social Media Analysis*, pp.55-64, June 2013.
- [25] A. S. Aruna, and P. K. Wilson, Sentiment Analysis using Linguistic Structures-(Adv-Adj-Noun), in *International Journal of Advanced Research in Computer Science*, vol.5, no.1, 2014.
- [26] R. Pandarachalil, S. Sendhilkumar, and G. S. Mahalakshmi, Twitter Sentiment Analysis for Large-Scale Data: An Unsupervised Approach, *Cognitive Computation*, pp.1-9, 2015.
- [27] A. Pak, and P. Paroubek, Twitter as a Corpus for Sentiment Analysis and Opinion Mining, in *LREC*, vol.10, pp.1320-1326, 2010.
- [28] X. Zhu, S. Kiritchenko, and S. M. Mohammad, Nrc-canada-2014: Recent improvements in the sentiment analysis of tweets, *SemEval 2014*, 2014.

Lamia Ali Al-Horaibi received her M.S. degree in Information Systems from Al-Imam Muhammad Ibn Saud Islamic University (ImamU), Saudi Arabia, in 2016. She is working now as system analyst and developer in Princess Nourah bint Abdulrahman University, Saudi Arabia.

Muhammad Badruddin Khan He received his PhD degree from Tokyo Institute of Technology, Japan. He is currently an assistant professor in the Department of Information Systems, College of Computer and Information Sciences, Al-Imam Muhammad ibn Saud Islamic University.