CHAPTER IV

EXPERIMENTAL RESULTS

The proposed algorithm are tested with four test sets. Each test set composes of two classes of two dimensional input data. The first test set is shown in Fig. 3.3. Each center vector is at non-optimal location. In Fig. 3.4, the center is adjusted to the position that achieves a higher degree of fault immunization. Table 4.1 shows the values obtained from the test: hidden unit number, initial immunization degree and final immunization degree.

Hidden unit No.	Initial immunization degree (F_k) (%)	Final immunization degree (F_k) (%)
1	62.987779	82.304011
2	80.235047	85.064070
Average immunization degree	71.611413	83.684041

Table 4.1: The comparison of the improvement of the immunization degree for test set 1.

The total increase of immunization degree is 12.072628% with the standard deviations (SD) of the hidden units is 0.072436.

The second test set contains two classes that are not separable by linear or quadratic

discrimination functions. The distributions of the classes are described by an equation with certain boundary constraints shown in the following.

$$(y - y_0)^2 = \frac{b}{a}(x - x_0)^2 + G(0, c), with \quad x_u \leq x \leq x_v, \tag{4.1}$$

where (x_0, y_0), (x_u, y_v) and (a, b, c) are three sets of parameter that determine the location and shape of the sample distribution. $G(0, c)$ is a Gaussian noise function with a mean value equal to zero and a variance equal to a constant value c. The snapshot of the learning process and the result of relocating the center vector for each test sets are illustrated in Tables 4.2, 4.3, and 4.4. For the Table 4.2(c), Table 4.3(c) and Table 4.4(c), the ellipses represent the hidden units which are at the non-optimal location, and the dotted ellipses represent the hidden units which are at the positions that achieve the higher immunization degree.

The third test set involves the training samples in two classes that are distributed in the way that are separable evenly by quadratic discriminate functions. The samples are described by system of three sine functions in the from of

$$y = sin(x - x_0) + G(0, c) \tag{4.2}$$

where (x_0, y_0), (x_u, y_v) and (a, b, c) are three sets of parameters that determine the location and shape of the sample distribution. $G(0, c)$ is a Gaussian noise function with a mean value equal to zero and a variance equal to a constant value c. The samples with different c are shown in Tables 4.5, 4.6 and 4.7. For the Table 4.5(c), Table 4.6(c), and Table 4.7(c), the ellipses represent the hidden units which are at the non-optimal location, and the dotted ellipses represent the hidden units which are at the positions that achieve the higher immunization degree.

The fourth test set contain two classes distributed in a ring-shaped region. The distributions are described by a system of three quadratic equations in the from of

$$(y - y_0)^2 = \frac{b}{a}(x - x_0)^2 + G(0, c) \tag{4.3}$$

where the parameters are the same as those that are use in test set 1. The sample sets with different $G(0, c)$ values are shown in Tables 4.8, 4.9 and 4.10. For the Table 4.8(c), Table 4.9(c) and Table 4.10(c) the ellipses represent the hidden units which are at the non-optimal location, and the dotted ellipses represent the hidden units which are at the positions that achieve the higher immunization degree.

Table. 4.11 compares the improvement of the immunization degree of the test sets and shows the values obtained from the tests: number of used hidden unit, average epochs, correct classification rate obtained from this thesis and [5] before fault immunization. In test set 3, the comparison is not applicable because the sinusoidal curves in this thesis and those in [5] are different in characteristics.

Table 4.12 compares the improvement of the immunization degree of the test sets and shows the values obtained from the tests: number of used hidden unit, initial immunization degree (F_k), final immunization degree (F_k), increased immunization degree (F_k) and the standard deviations (SD) of the hidden units.

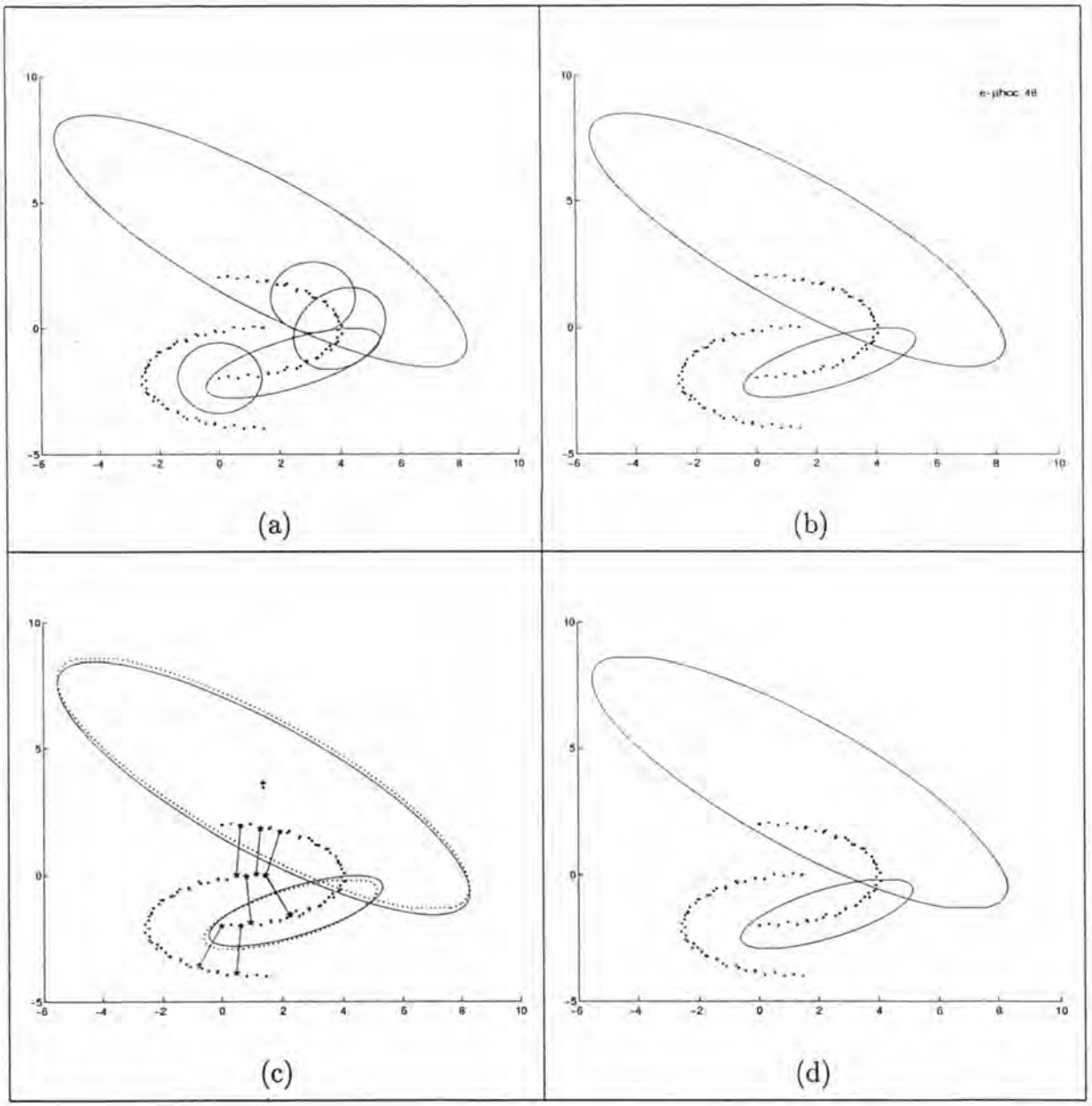

Table 4.2: The results of test set 2_1 (half circle distributions): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

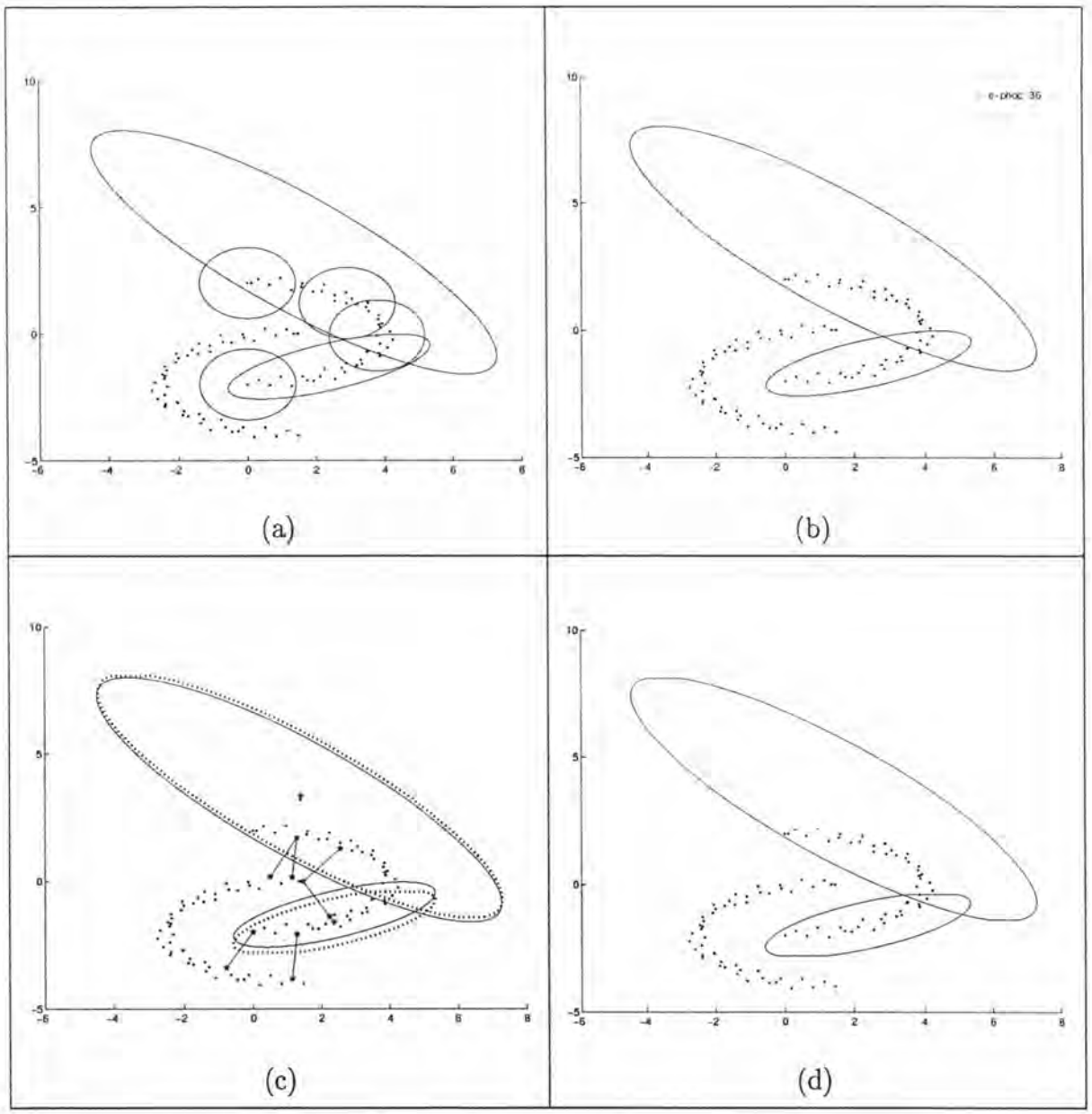

Table 4.3: The results of test set 2_2 (half circle distributions): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

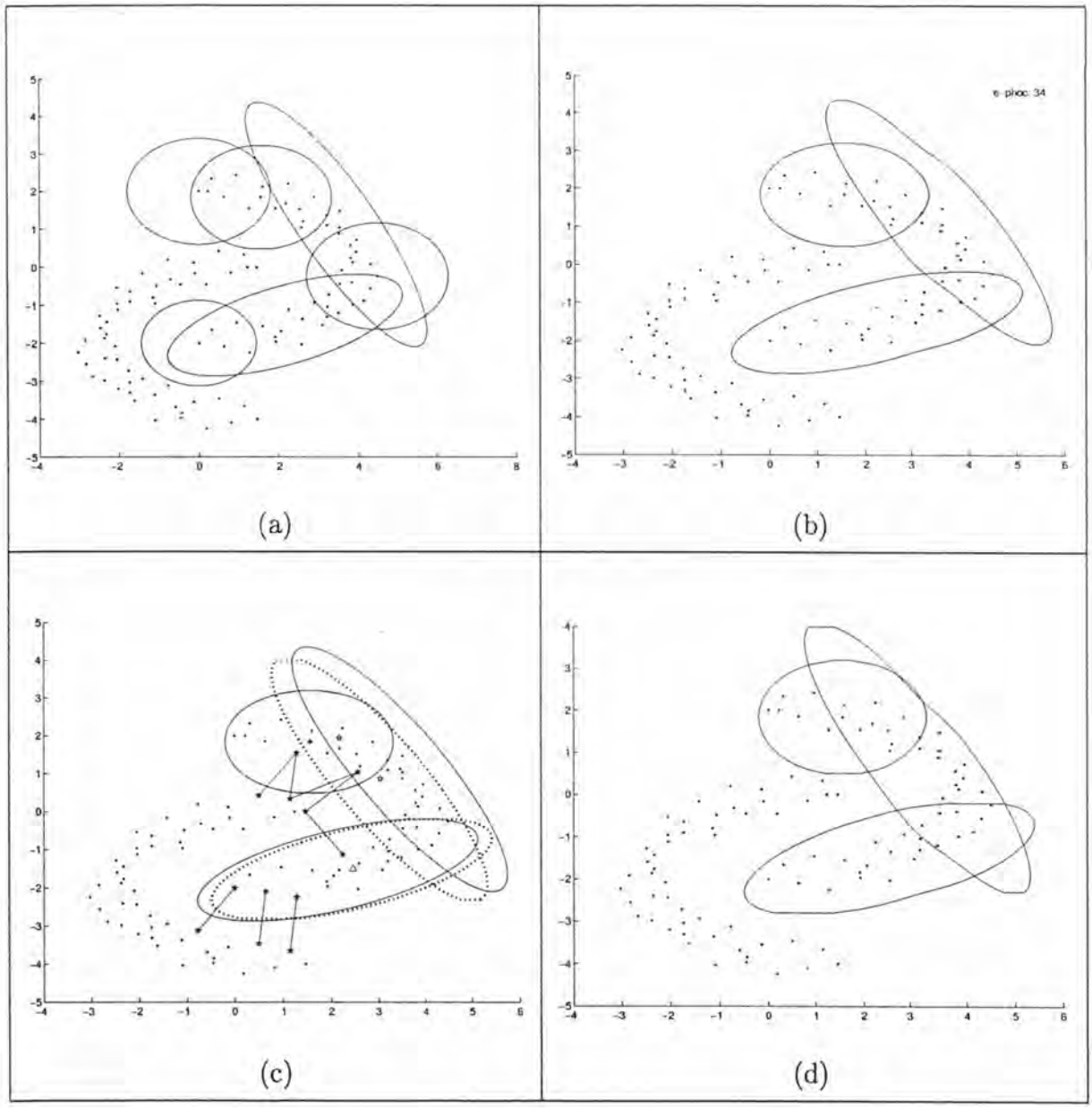

Table 4.4: The results of test set 2_3 (half circle distributions): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

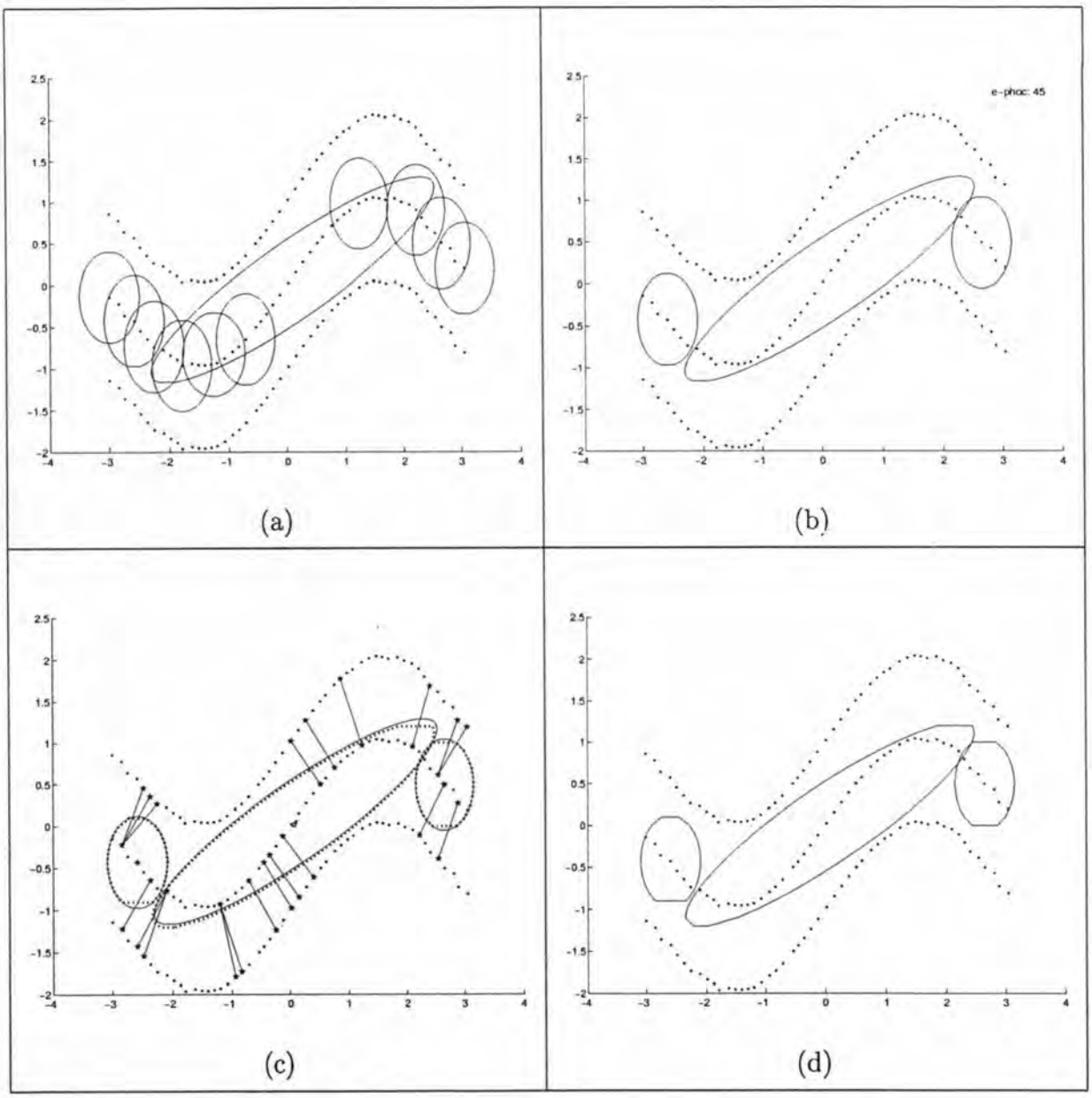

Table 4.5: The results of test set 3_1 (different distribution sinusoidal curve): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

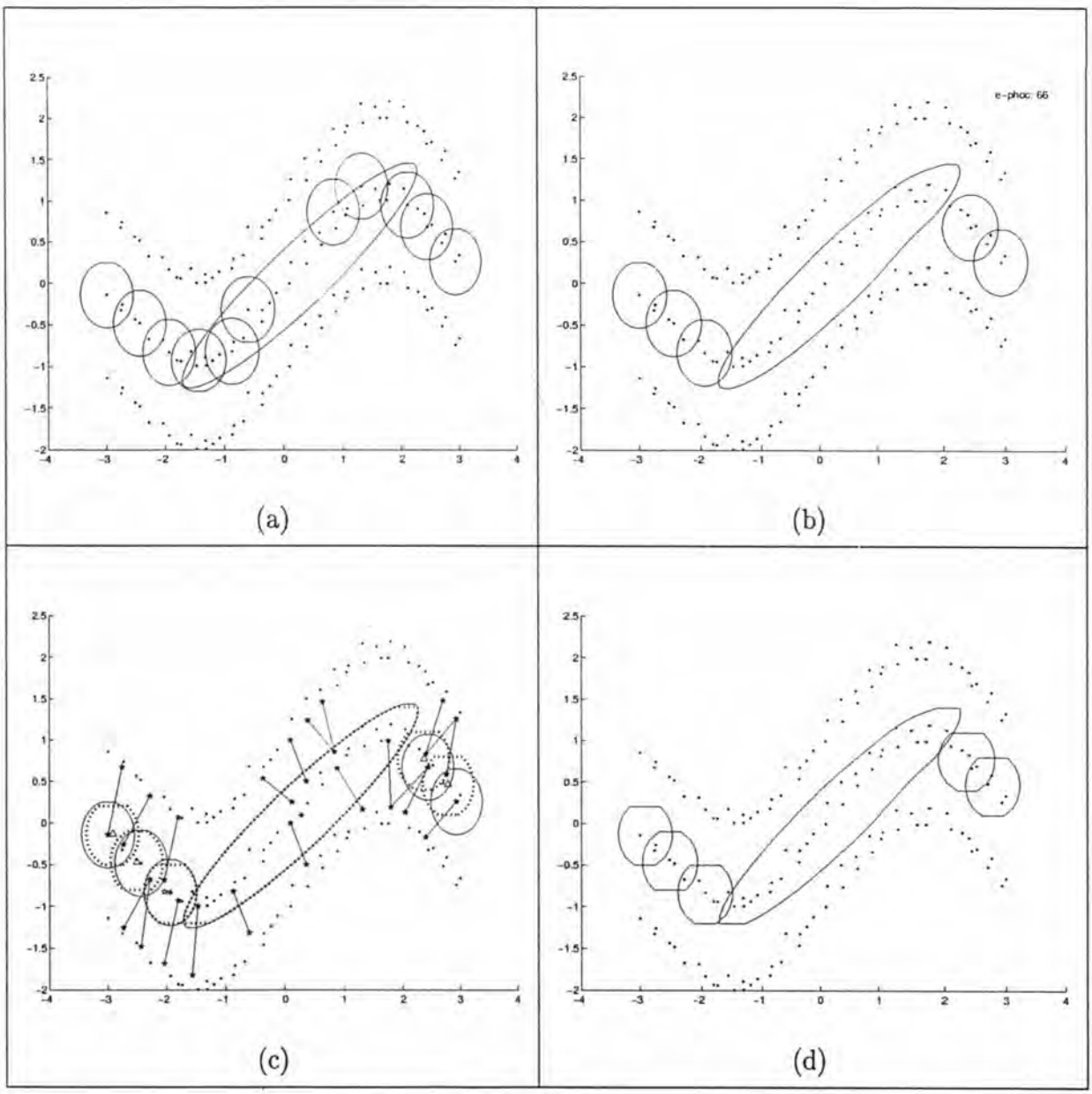

Table 4.6: The results of test set 3_2 (different distribution sinusoidal curve): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

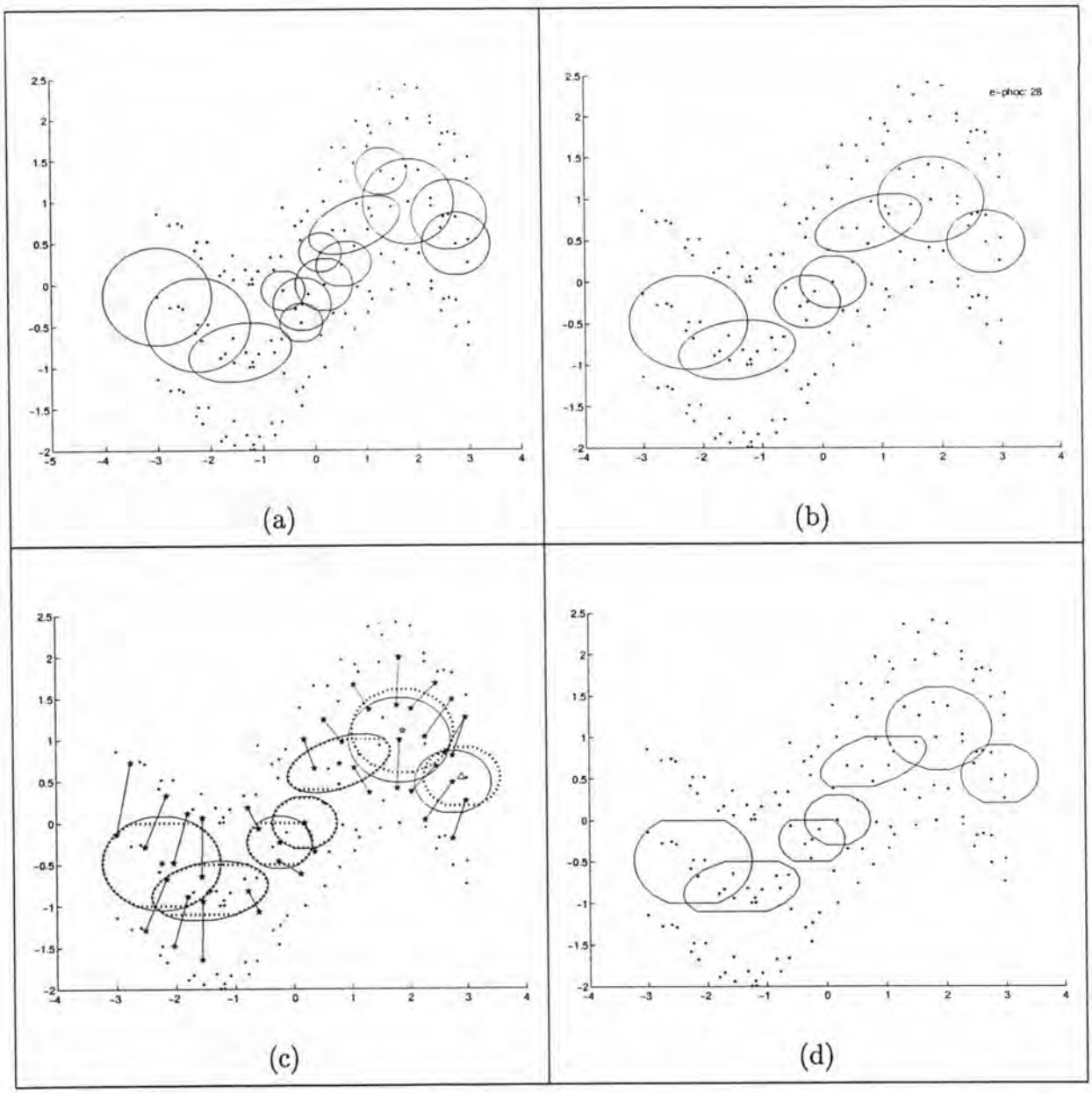

Table 4.7: The results of test set 3_3 (different distribution sinusoidal curve): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

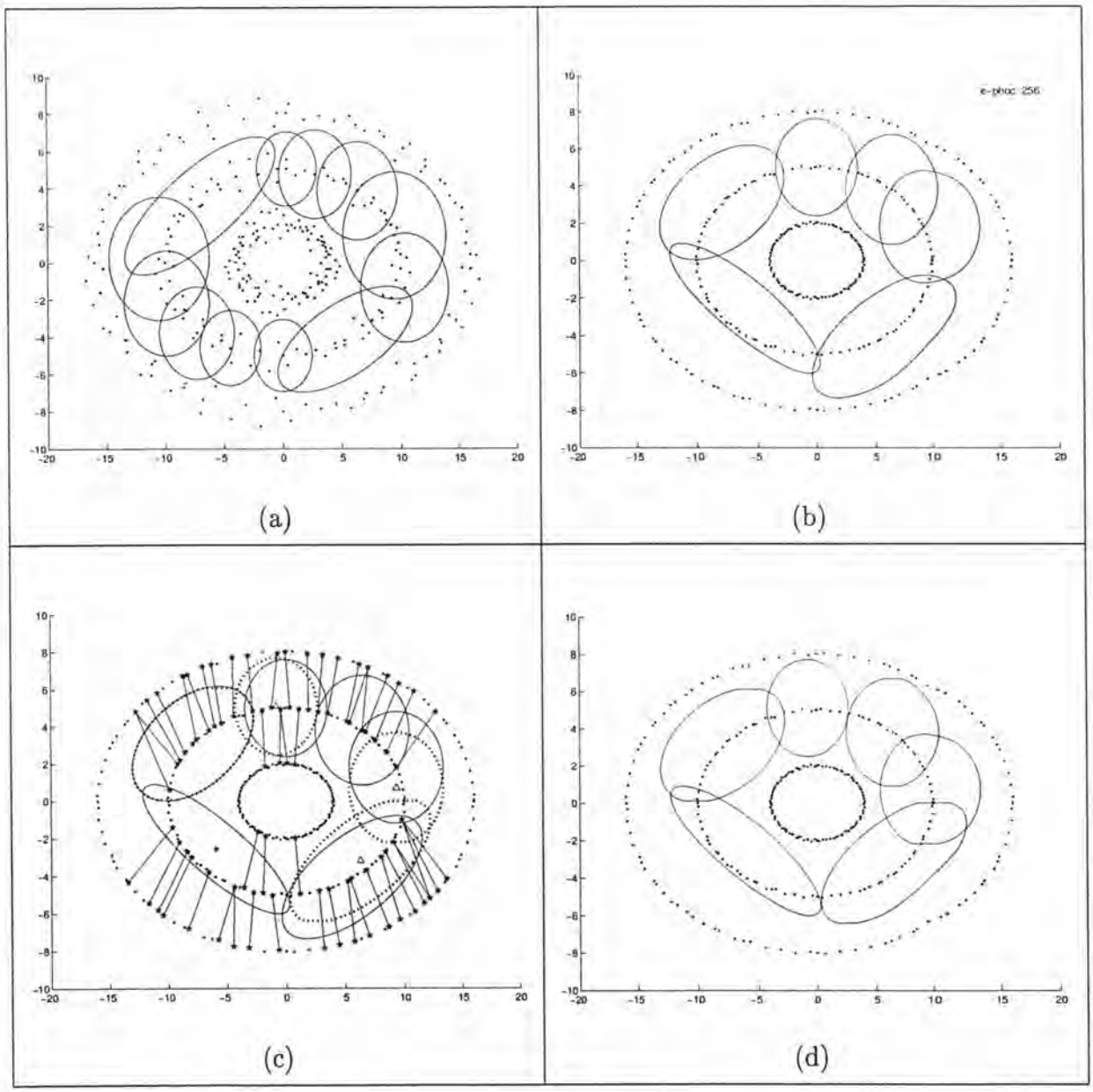

Table 4.8: The results of test set 4_1 (ring-shaped distributions): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

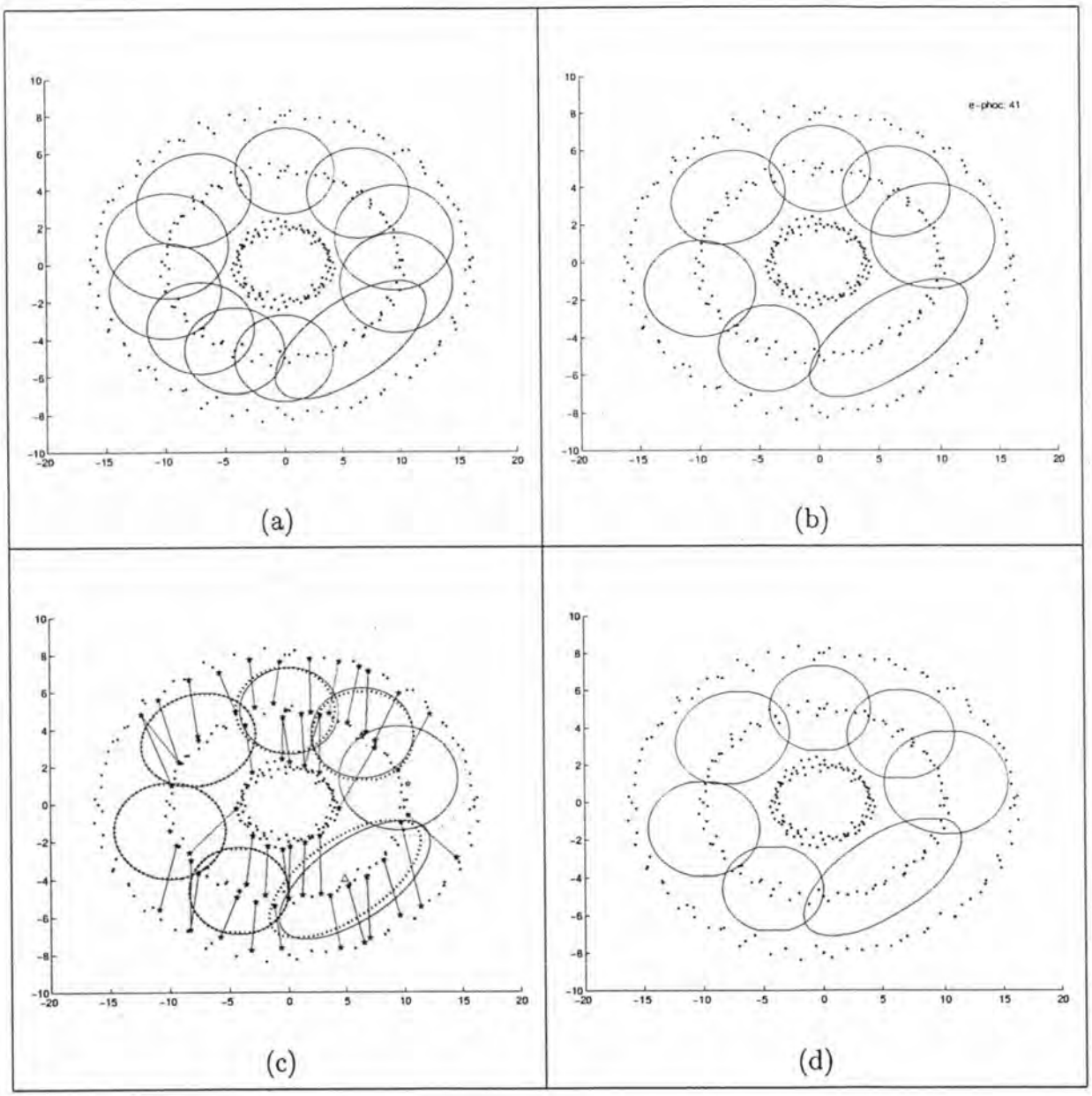

Table 4.9: The results of test set 4_2 (ring-shaped distributions): (a) The result before pruning. (b) The result after pruning. (c) All the nearest data vectors pairs. (d) The result after fault immunization.

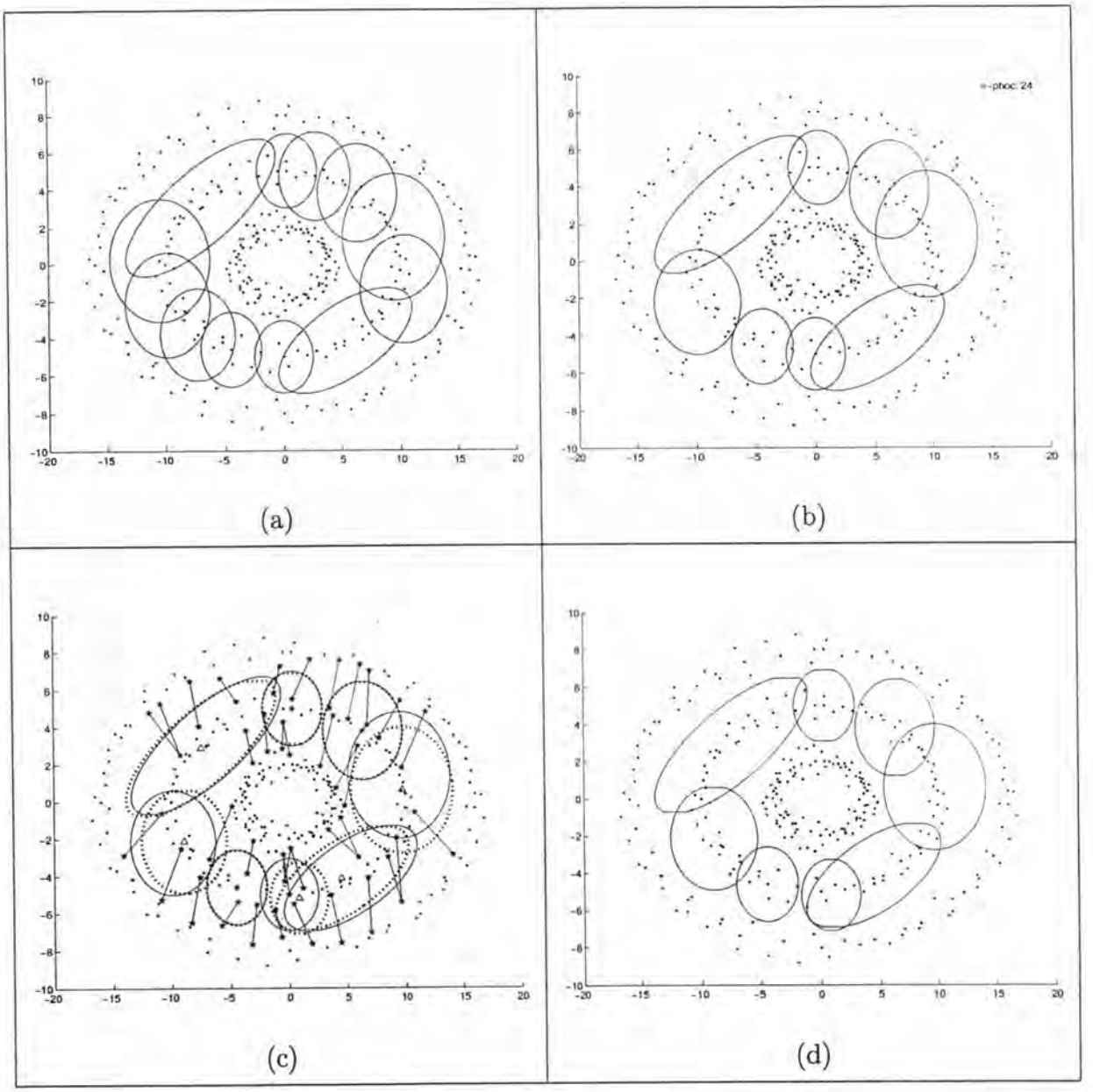

Table 4.10: The results of test set 4_3 (ring-shaped distributions): (a) The result before pruning (b) The result after pruning (c) All the nearest data vectors pairs (d) The result after fault immunization.

Test set	Number of hidden units	Number of hidden units[5]	Epochs	Epochs [5]	Correct classification rate (%)	Correct classification rate[5] (%)
2_1	2	3	48	61	95.00	94.20
2_2	2	4	36	73	95.00	94.68
2_3	3	4	34	123	99.00	94.97
3_1	3	-	45	-	95.80	-
3_2	6	-	66	-	95.48	-
3_3	7	-	28	-	89.00	-
4_1	6	7	256	230	100.00	94.17
4_2	7	7	41	384	94.00	95.00
4_3	8	8	24	579	95.00	94.03

Table 4.11: The comparison of the results (number of hidden units, average epochs and percentage of correct classification rate) obtained from this thesis and [5] before fault immunization.

Test set	Number of hidden units	Initial immunization degree (F_k) (%)	Final immunization degree (F_k) (%)	Increase immunization degree (F_k) (%)	SD
2_1	2	54.364500	63.747500	9.383000	0.015184
2_2	2	54.722200	71.699050	16.97690	0.089551
2_3	3	40.722333	66.525867	25.80353	0.260940
3_1	3	54.159600	56.052567	1.892967	0.025239
3_2	6	47.683817	50.714783	3.030950	0.036309
3_3	7	49.886343	54.958829	5.072486	0.079302
4_1	6	39.787300	48.125033	8.337733	0.083377
4_2	7	46.148757	55.152014	9.003257	0.180528
4_3	8	47.324038	55.407650	8.083625	0.077068

Table 4.12: The comparison of the improvement of the immunization degree for each test set.