Scan-Along Polygonal Approximation for Data Compression of Electrocardiograms

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Outline

1. INTRODUCTION
2. ALGORITHMS
3. EXPERIMENTAL RESULTS
4. SUMMARY AND CONCLUSIONS

1. INTRODUCTION

- SAPA於1983年被ISHIJIMA提出
- 隨後在1985年被證明他使用的是扇形演算法
- 但有近10年的時間被認定是ECG最好的適應性取樣法

2. ALGORITHMS

- 提出的演算法有SAPA-1, SAPA-2和SAPA-3
- SAPA-1有壓縮率最差但是執行時間較短
- SAPA-3擁有高壓縮率但是執行時間較長

2. ALGORITHMS

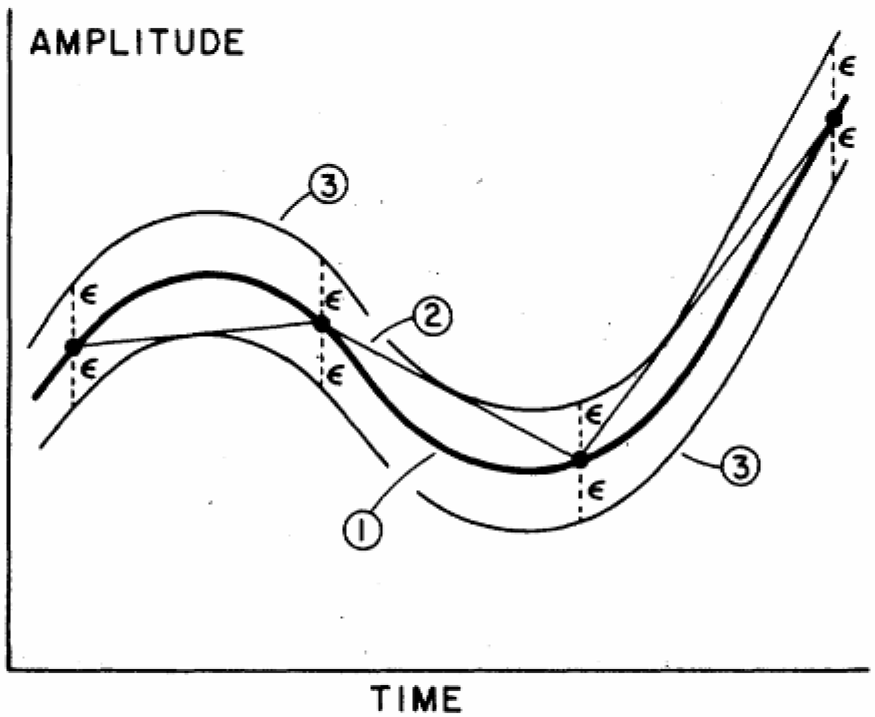


Fig. 1. Basic concept of polygonal approximation. ① Original signal. ② Polygonal approximation of original signal. ③ Approximation error boundary.

2. ALGORITHMS

A. Sideline Criteric

$$g(c,\varepsilon) = \frac{w(c) + \varepsilon - w(s)}{c - s}$$

$$g(c,-\varepsilon) = \frac{w(c) - \varepsilon - w(s)}{c - s}$$

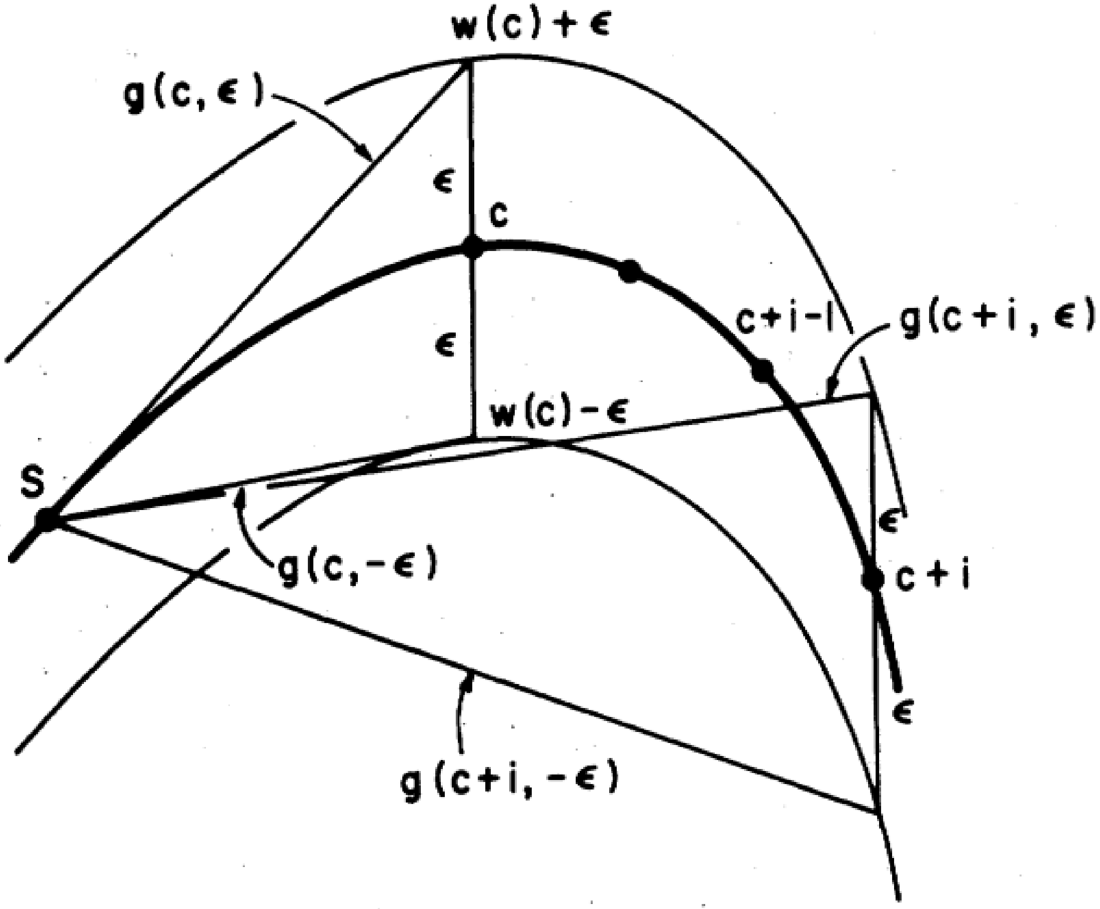


Fig. 2. Illustration of SAPA-1 algorithm.

2. ALGORITHMS

SAPA-1

- g(*c*, ε)的值存為m_1
- g(*c*, - ε)的值是存為m_2,即$m_1 > m_2$
- 直到k=c+i的狀態時$m_2 > m_1$,則將k=c+i-1的位置和振幅儲存並設為頂點

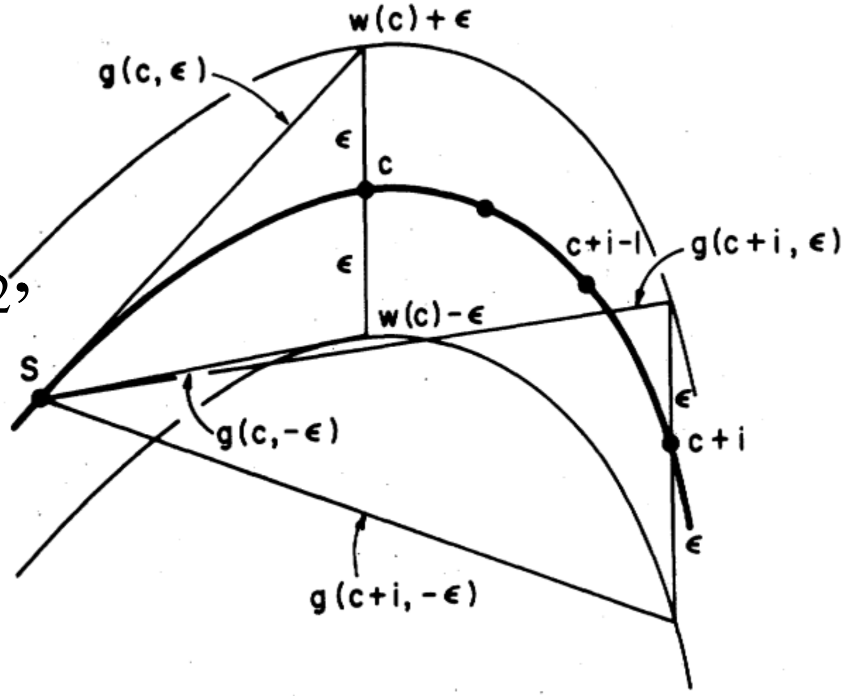
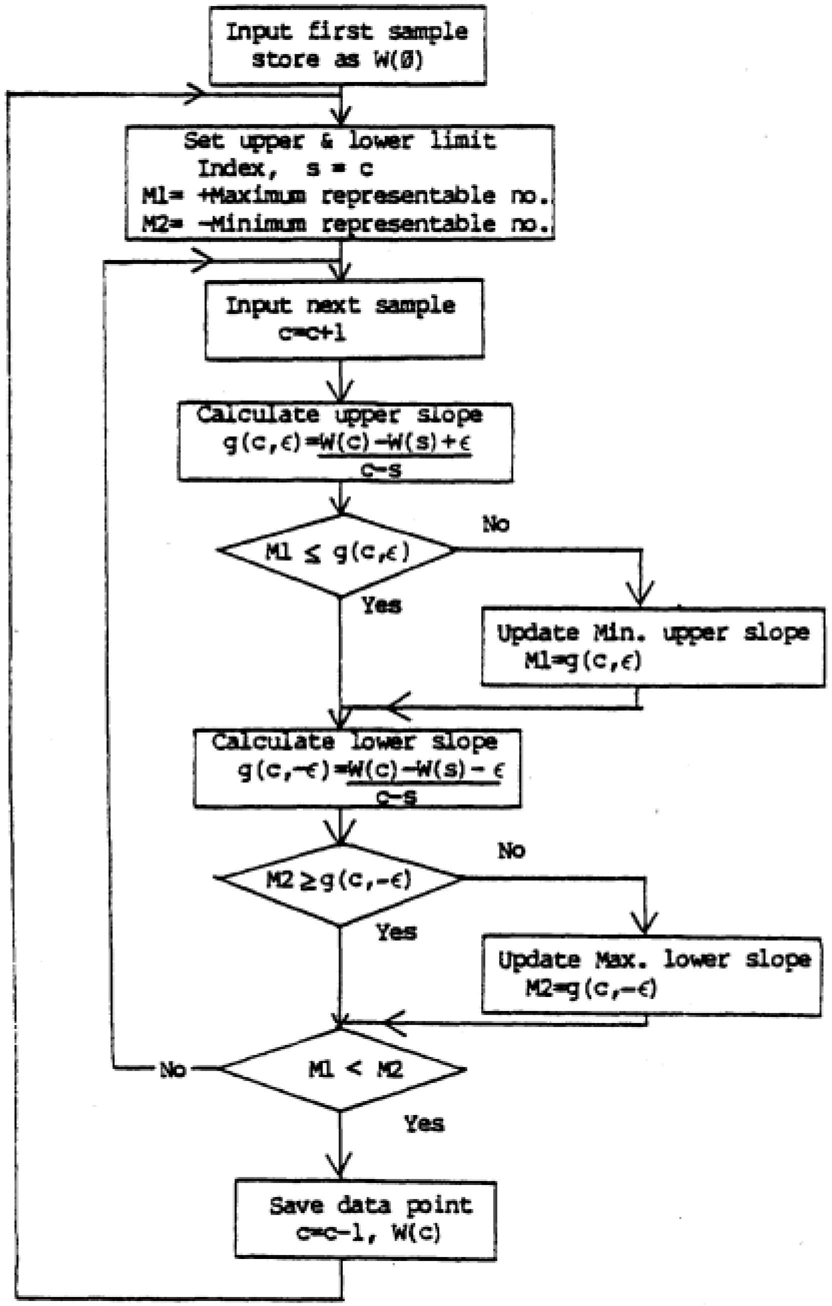


Fig. 2. Illustration of SAPA-1 algorithm.

2. ALG

- SAP/



Input first sample
store as W(Ø)
Set upper & lower limit
Index, s = c
M1= +Maximum representable no.
M2= -Minimum representable no.
Input next sample
c=c+1
Calculate upper slope
g(c,ε)=W(c)-W(s)+ε / c-s
M1 ≤ g(c,ε)
No
Yes
Update Min. upper slope
M1=g(c,ε)
Calculate lower slope
g(c,-ε)=W(c)-W(s)-ε / c-s
M2 ≥ g(c,-ε)
No
Yes
Update Max. lower slope
M2=g(c,-ε)
No
M1 < M2
Yes
Save data point
c=c-1, W(c)

2. ALGORITHMS

B. Centerline Criterion, SAPA-2

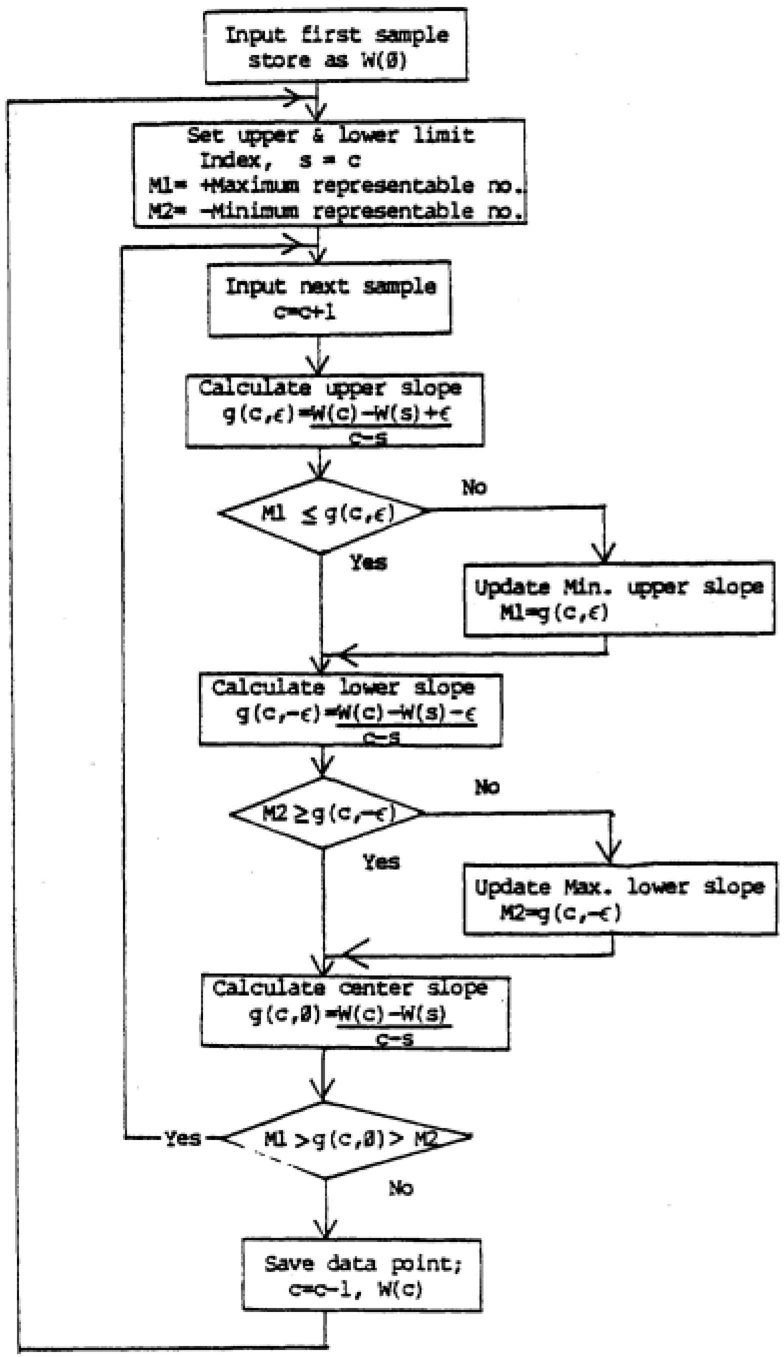
- 加入 $g(c,0)=\dfrac{w(c)-w(s)}{c-s}$

- 必須 $m_1>g(c+i,\ 0)>m_2$

2. ALGOR

- SAPA-2

SAPA-2 Flow Diagram



2. ALGORITHMS

- SAPA-2

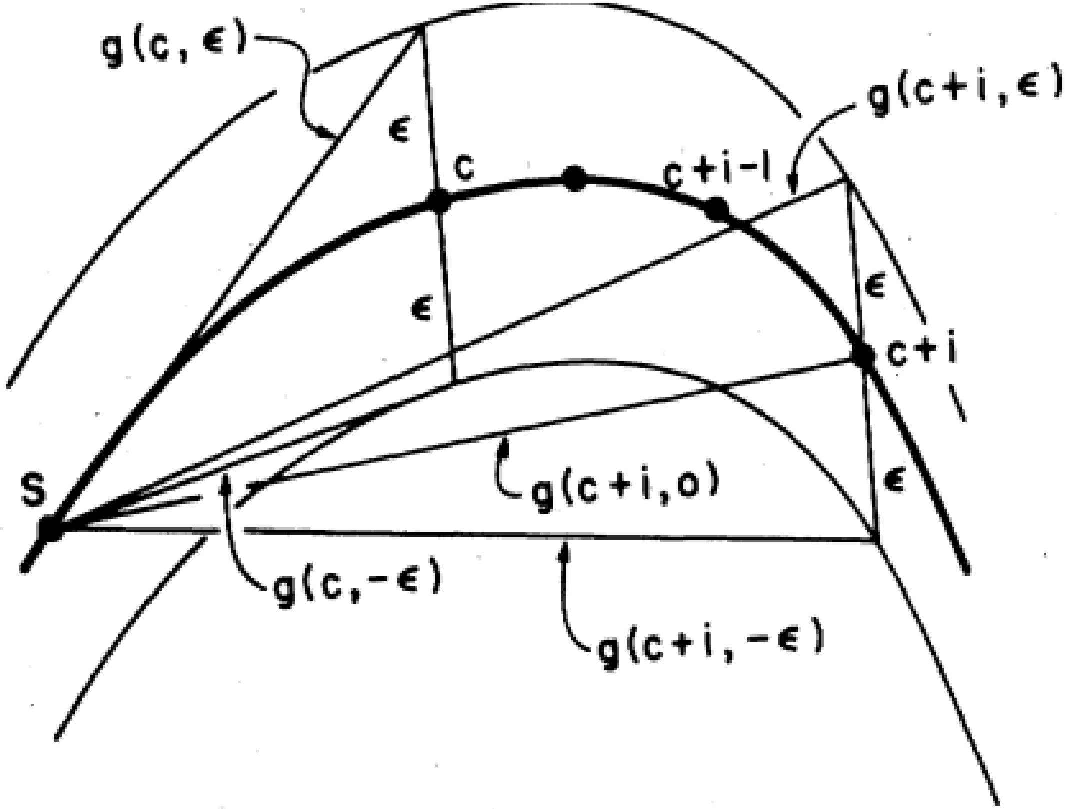


Fig. 3. Illustration of SAPA-2 algorithm.

2. ALGORITHMS

- SAPA-2

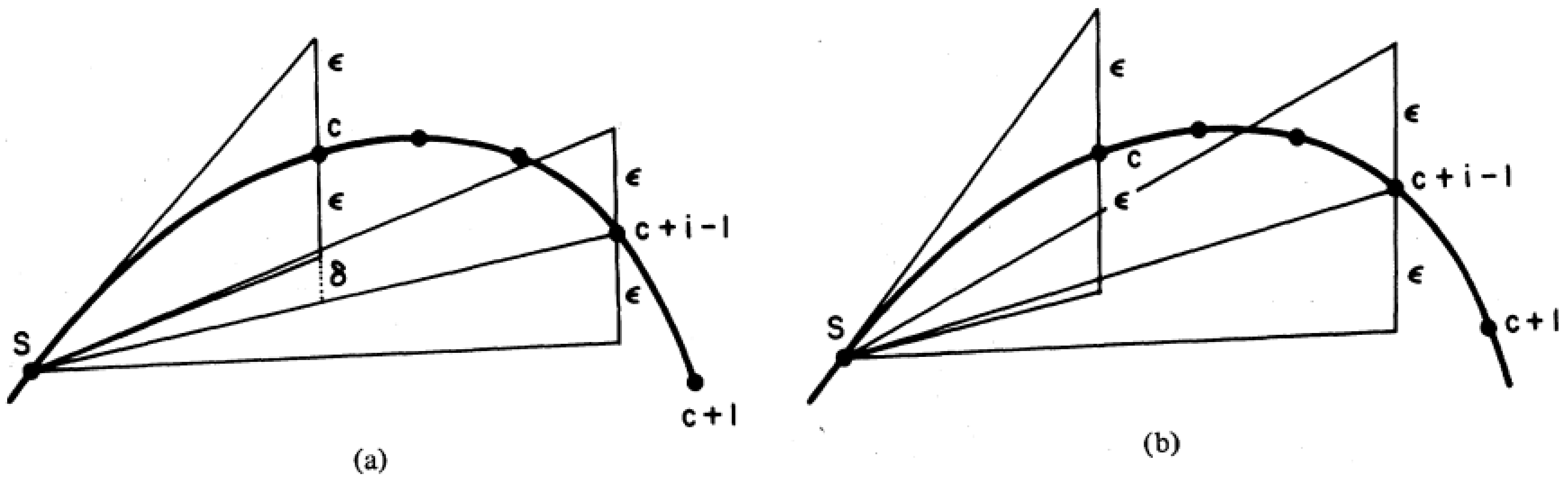


Fig. 4. Distinction between SAPA-1 and SAPA-2 performances. (a) SAPA-1 compression. (b) SAPA-2 compression.

2. ALGORITHMS

- C. Extended Centerline Criterion, SAPA-3

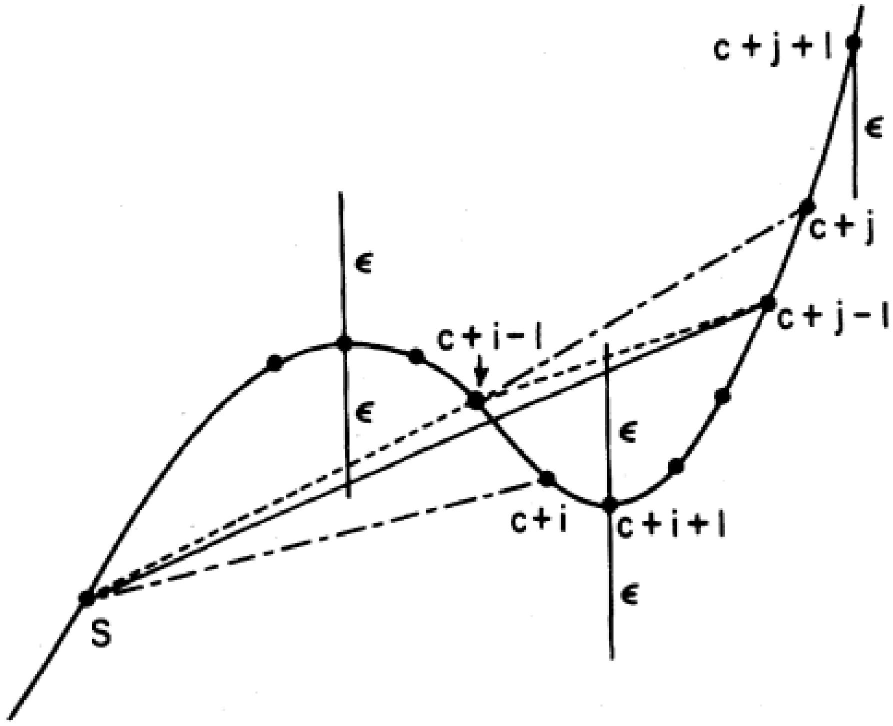


Fig. 5. Illustration of SAPA-3 algorithm.

3. EXPERIMENTAL RESULTS

- Data form our laboratory:200~1000 samples/s, 12 –bit data, 1-channel
- AHA arrhythmia database:250 sample/s, 12-bit, 2 channel
- ECG data form Rancho Los Amigos Hospital:1000 samples/s,16-bit data, 12 channel

3. EXPERIMENTAL RESULTS

TABLE I
COMPARISON OF ALGORITHM EXECUTION TIMES ON THE 500 Hz SAMPLED DATA

	SAPA-1	SAPA-2	SAPA-3	TOMEK	AZTEC
Number of divisions to process one sample (16-bit)	2	3	5	2	0
Maximum execution time for processing one data point (msec)	1.2	1.9	2.6	1.4	0.3
Typical compression ratio (at 500 Hz sample ratio)	9	11	10	10	6

13

3. EXPERIMENTAL RESULTS

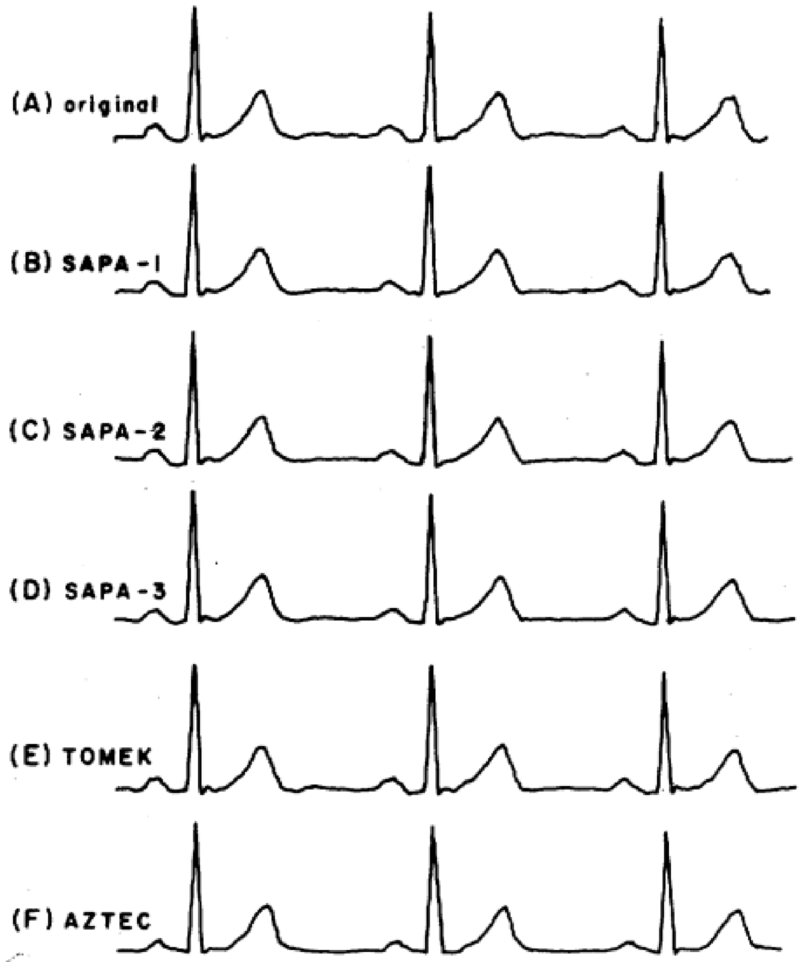


Fig. 6. Noise-free electrocardiogram data processed by various algorithms.

3. EXPERIMENTAL RESULTS

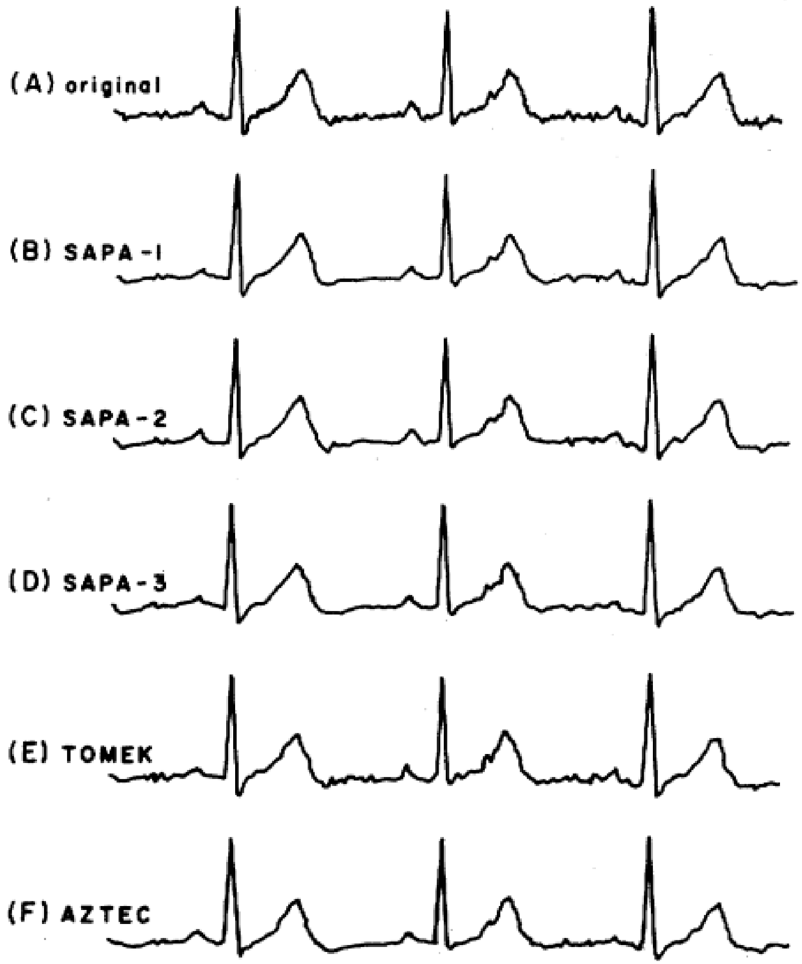


Fig. 7. Noisy electrocardiogram data processed by various algorithms.

3. EXPERIMENTAL RESULTS

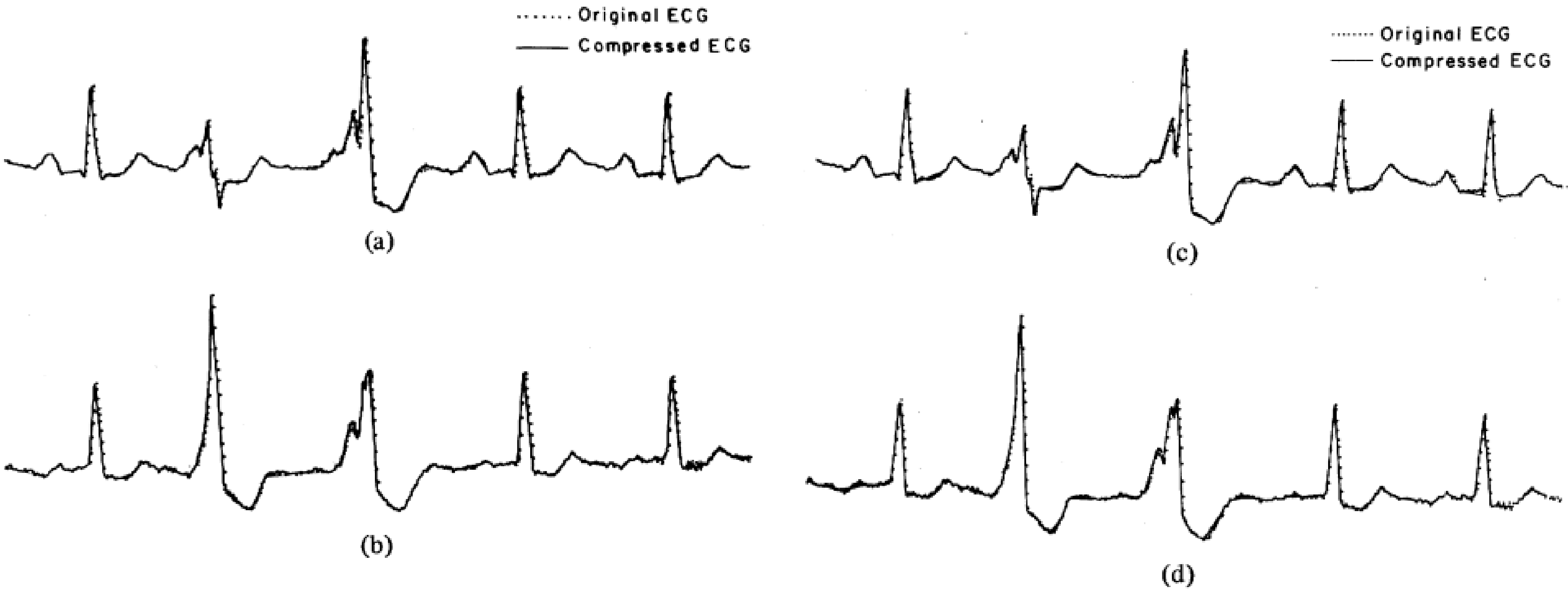


Fig. 8. One pair of 2-channel data processed by SAPA-2 at two distinct ϵ limits. (a) Channel 1, $\epsilon = 20$. (b) Channel 2, $\epsilon = 20$. (c) Channel 1, $\epsilon = 25$. (d) Channel 2, $\epsilon = 25$.

4. SUMMARY AND CONCLUSIONS

- 在取樣率250Hz，5個心跳週期長度的不正常心電圖壓縮率可以達到10
- 在取樣率500Hz，3個心跳週期長度的正常心電圖壓縮率可以達到11
- 可以調整準確性
- 重建的的方式很簡單和直接