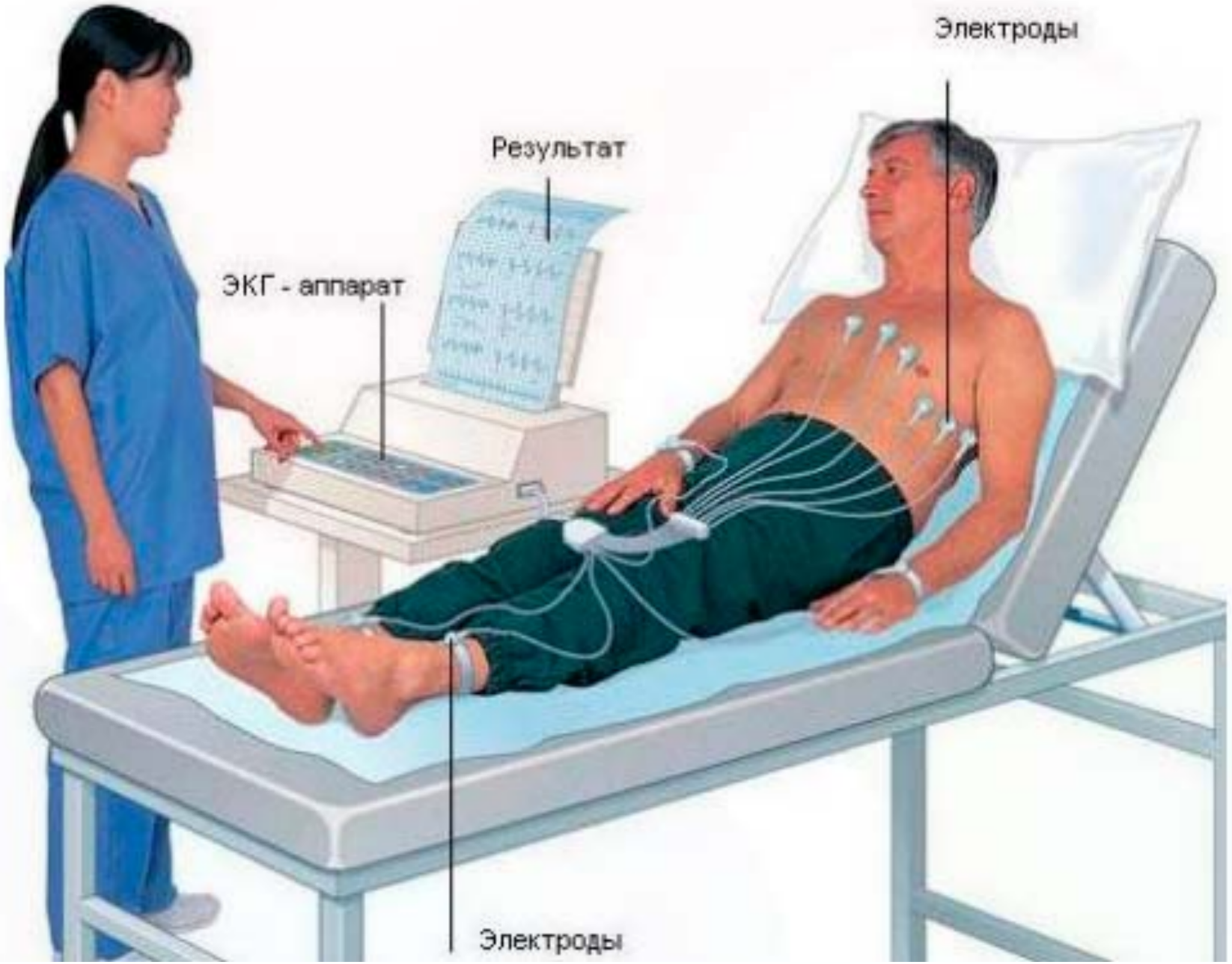
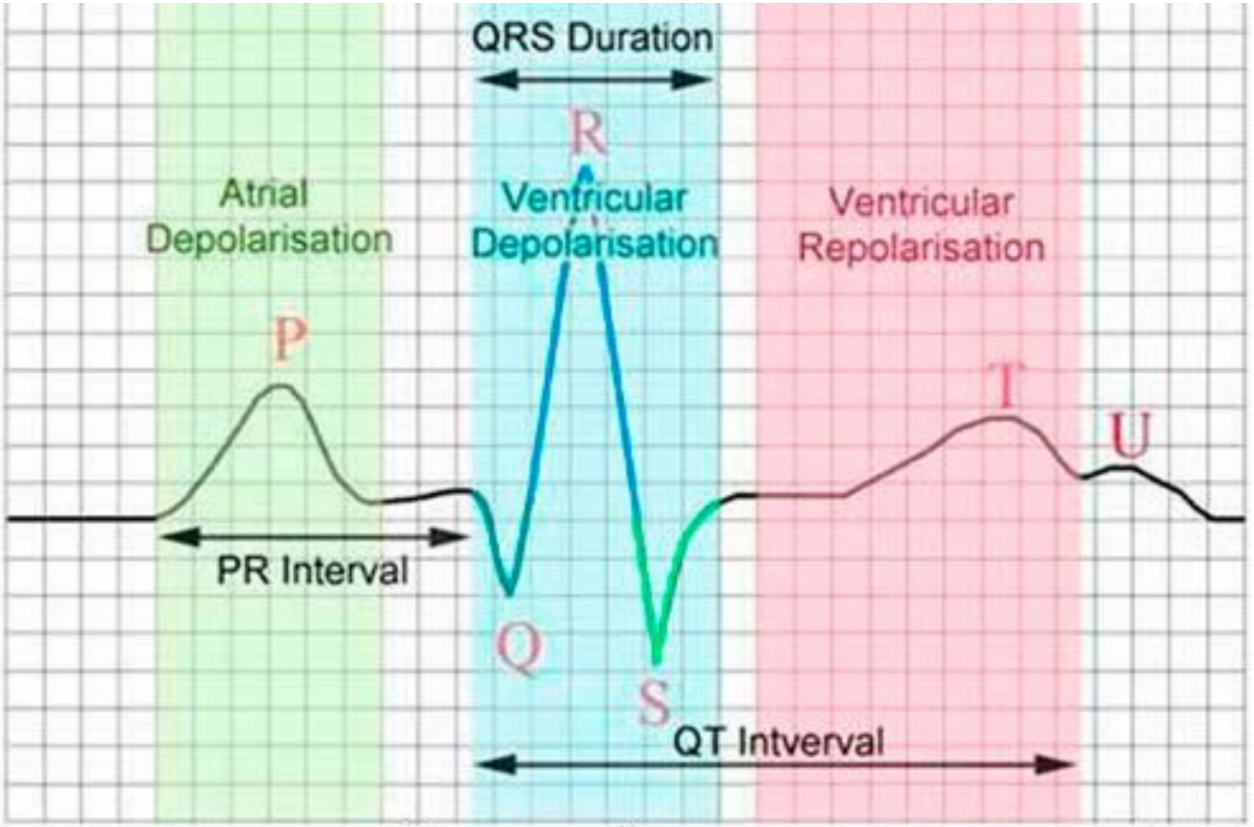
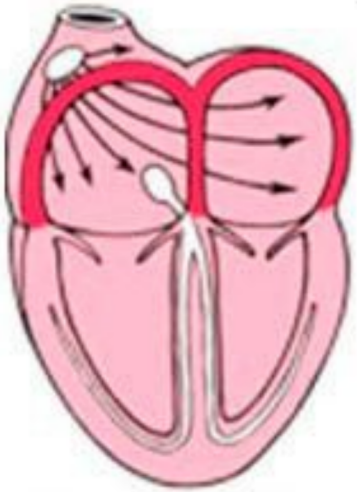
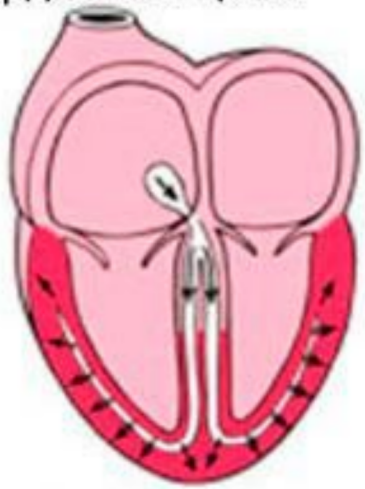

Электроды
Результат
ЭКГ - аппарат
Электроды



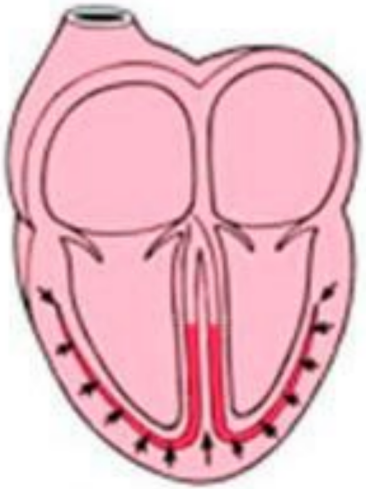
Сердечный цикл



Работа предсердия

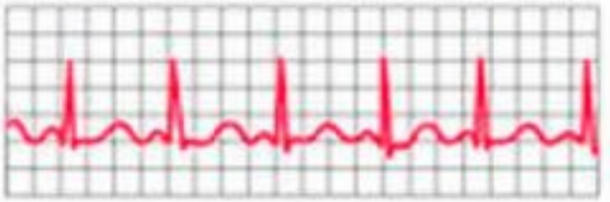


Работа желудочков

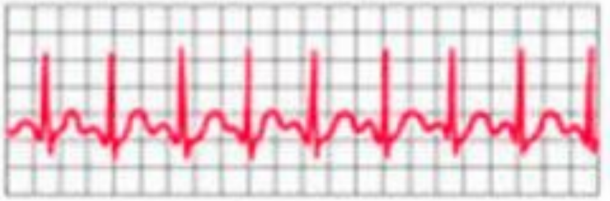


Восстановление

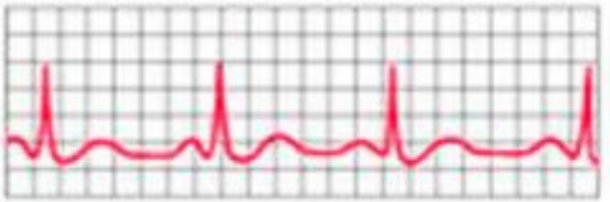
Нормальный сердечный ритм



Тахикардия

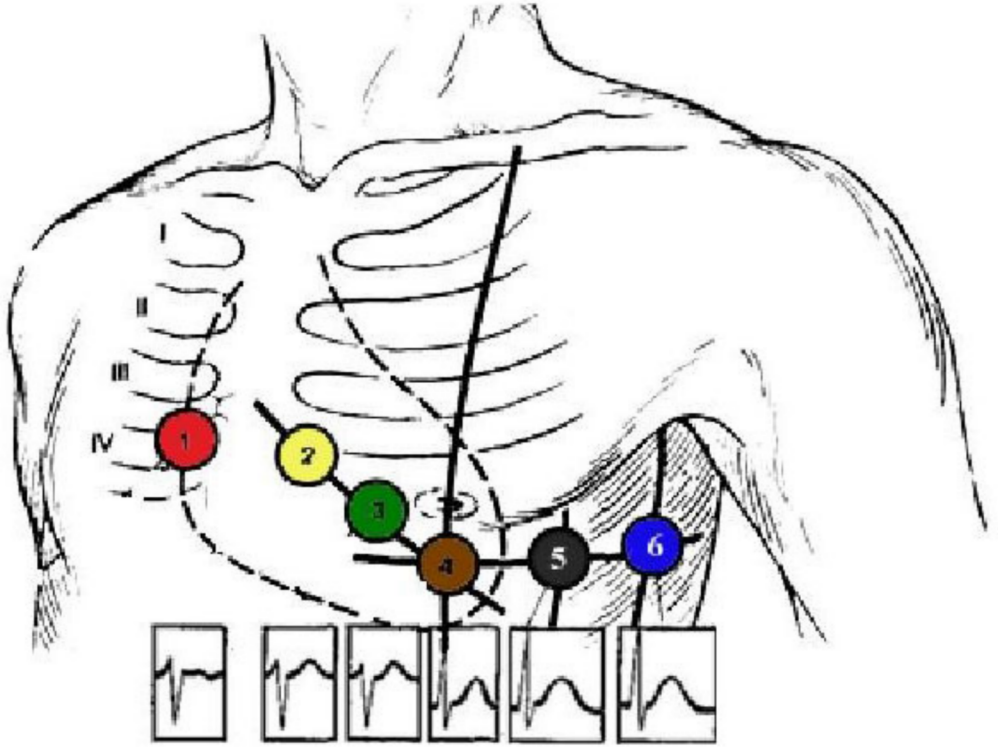


Брадикардия

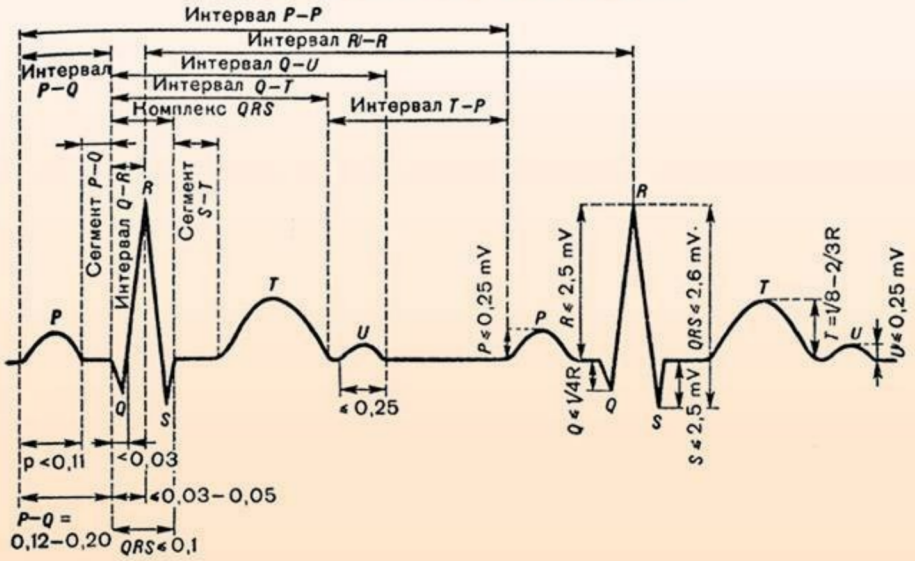


Аритмия

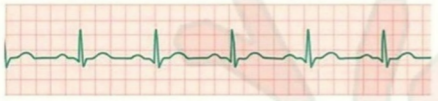
Грудные отведения



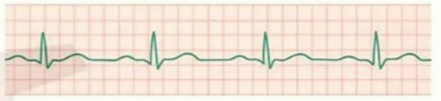
РАСШИФРОВКА ЭКГ



НОРМАЛЬНЫЙ СИНУСОВЫЙ РИТМ

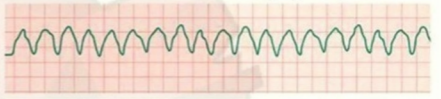


СИНУСОВАЯ БРАДИКАРДИЯ

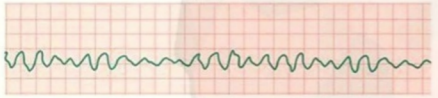


СИНУСОВАЯ ТАХИКАРДИЯ

ЖЕЛУДОЧКОВАЯ ТАХИКАРДИЯ



ФИБРИЛЛЯЦИЯ ЖЕЛУДОЧКОВ

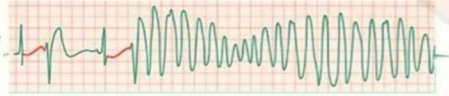


ФИБРИЛЛЯЦИЯ ПРЕДСЕРДИЙ

ЖЕЛУДОЧКОВАЯ ЭКСТРАСИСТОЛИЯ

АСИСТОЛИЯ

TORSADE DE POINTES ПИРУЭТНАЯ ТАХИКАРДИЯ



ТРЕПЕТАНИЕ ПРЕДСЕРДИЙ

Journal of Electrocardiology 80 (2023) 125–132

Contents lists available at ScienceDirect

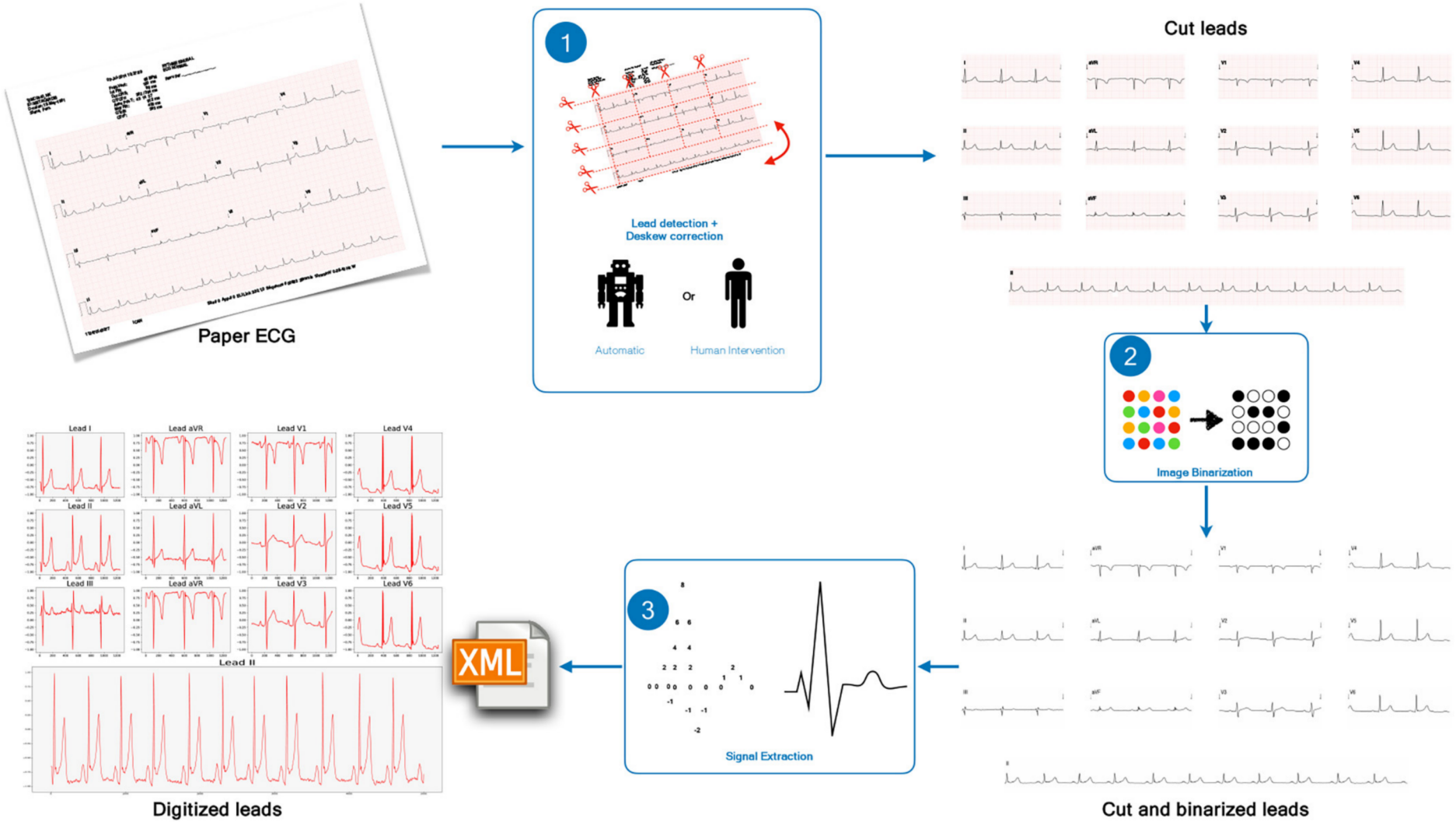
Journal of Electrocardiology

journal homepage: www.jecgonline.com

Review

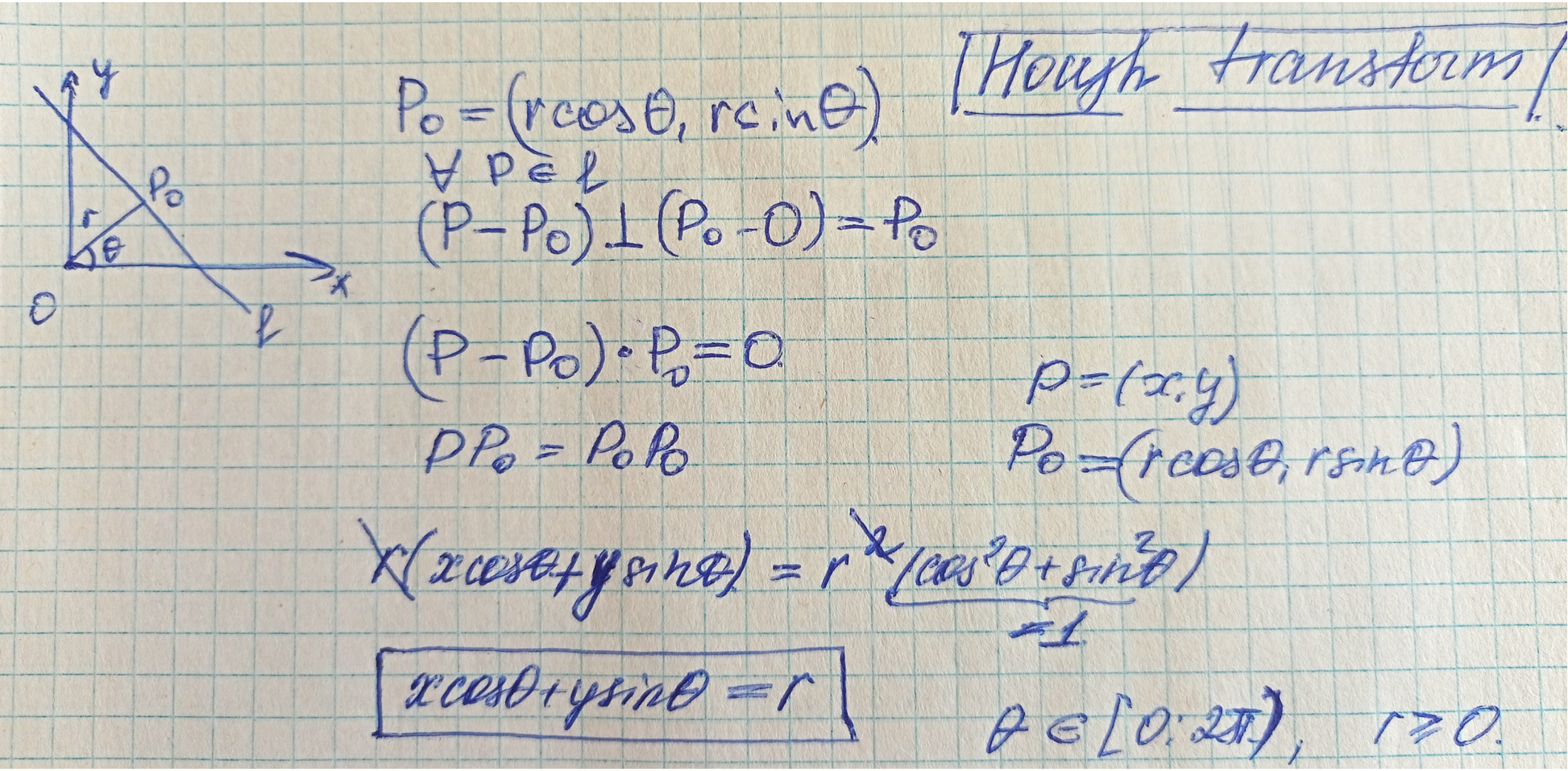
Automatic digitization of paper electrocardiograms – A systematic review

Alex Lence [a,*], Fabrice Extramiana [b,c], Ahmad Fall [a,d], Joe-Elie Salem [e,f], Jean-Daniel Zucker [a,g], Edi Prifti [a,g,*]



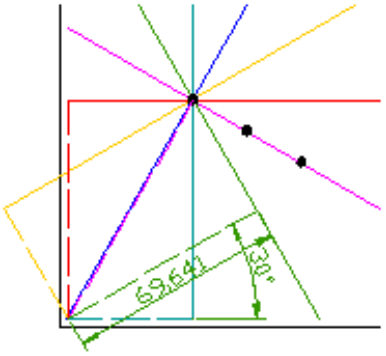
1. DeSKEWing

Преобразование Хафа (англ. Hough Transform)

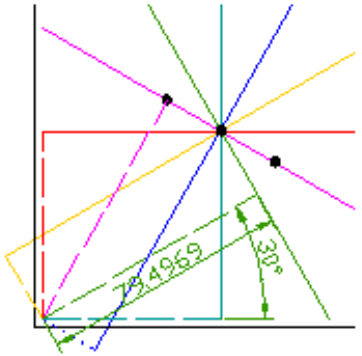


1. DeSKEWing

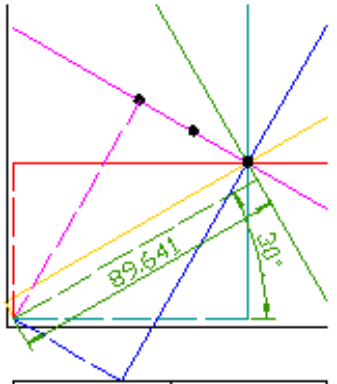
Преобразование Хафа (англ. Hough Transform)



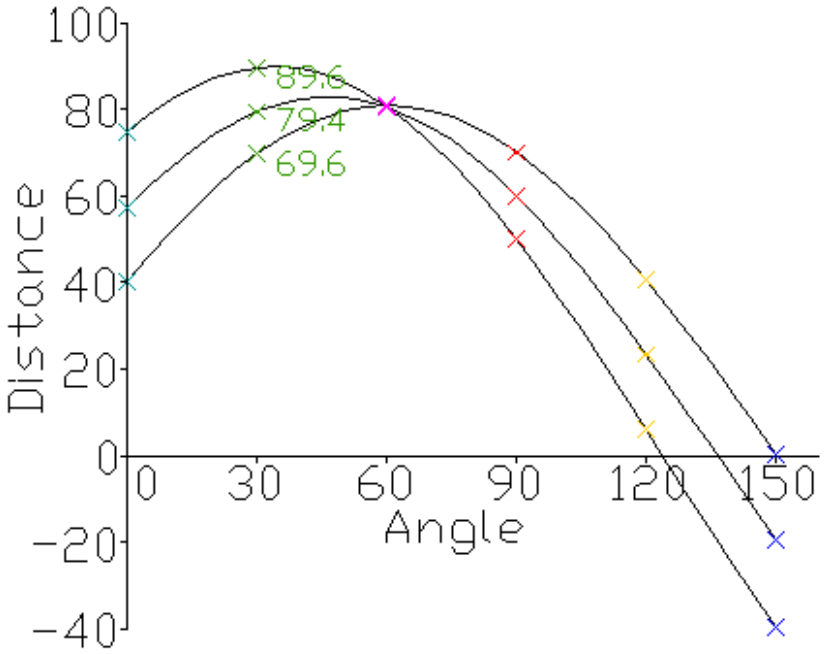
Angle	Dist.
0	40
30	69.6
60	81.2
90	70
120	40.6
150	0.4



Angle	Dist.
0	57.1
30	79.5
60	80.5
90	60
120	23.4
150	−19.5



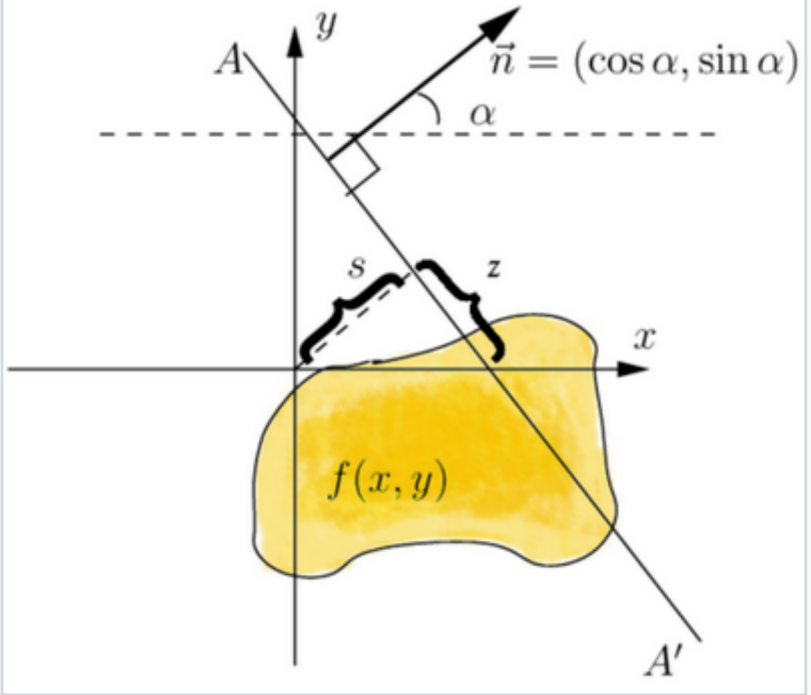
Angle	Dist.
0	74.6
30	89.6
60	80.6
90	50
120	6.0
150	−39.6



1. DeSKEWing

Преобразование Радона (англ. Radon Transform)

$$R(s,\alpha) = \int_{-\infty}^{\infty} f(s\cos\alpha - z\sin\alpha, s\sin\alpha + z\cos\alpha)dz \quad (1)$$

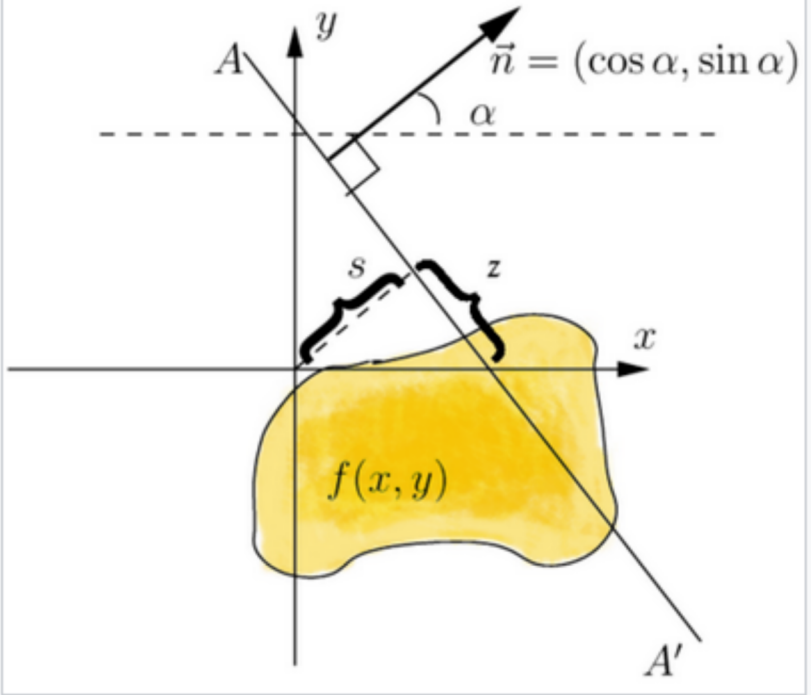


Двумерное преобразование Радона. В данном случае *R(s,α)* есть интеграл от *f(x, y)* вдоль прямой AA'

1. DeSKEWing

Преобразование Радона (англ. Radon Transform)

$$R(s,\alpha) = \int_{-\infty}^{\infty} f(s\cos\alpha - z\sin\alpha, s\sin\alpha + z\cos\alpha)dz \quad (1)$$



Двумерное преобразование Радона. В данном случае *R(s,α)* есть интеграл от *f(x, y)* вдоль прямой AA'

2. DeGRIDing

* Global thresholding
* Otsu

Метод Оцу ищет порог, уменьшающий дисперсию внутри класса, которая определяется как взвешенная сумма дисперсий двух классов:

$$\sigma_w^2(t) = \omega_1(t)\sigma_1^2(t) + \omega_2(t)\sigma_2^2(t),$$

где веса ω_i — это вероятности двух классов, разделённых порогом t,
σ_i^2 — дисперсия этих классов.

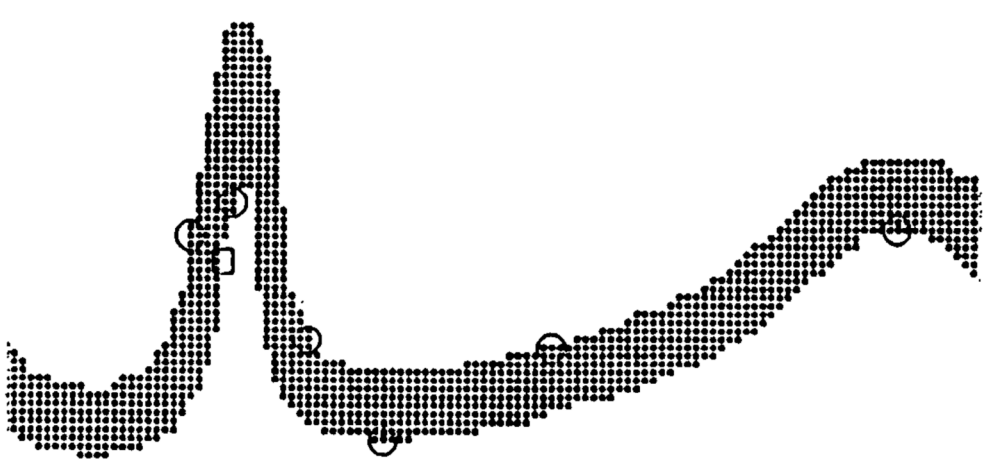
Оцу показал, что минимизация дисперсии *внутри* класса равносильна максимизации дисперсии *между* классами:

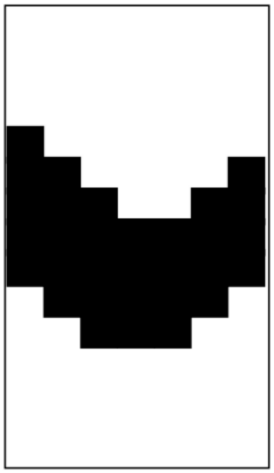
$$\sigma_b^2(t) = \sigma^2 - \sigma_w^2(t) = \omega_1(t)\omega_2(t)[\mu_1(t) - \mu_2(t)]^2$$

* Saulova
* Scan-line-polygon-filing
* Color segmentation

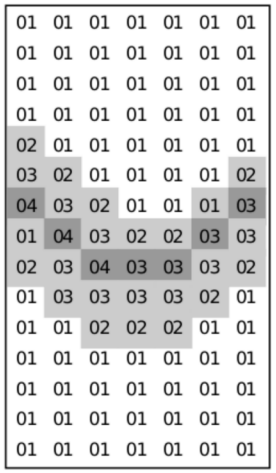
3. Signal extraction

* Strainght forward approach

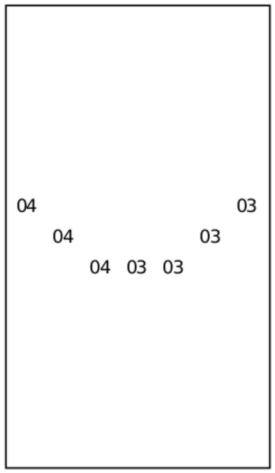




(a)



(b)



(c)

* Clustering-based approaches

* Minimization of mathematical functions
  (path length, path continuity and signal fidelity)

Journal of Network and Computer Applications (1996) **19,** 295–307

A microcomputer-based prototype for ECG paper record conversion

Jian Tao Wang and Dinesh P. Mital

Table 1
Articles considered for this review.

Reference	Dataset: Origin / Numbers of lead	Code or software accessibility	Noisy image Treatment	Human intervention	Deskew approach	Binarization approach	Signal Extraction
(Widman and Hines 1991) [1]	NA / 21 leads	False	NA	User intervention	NA	NA	Line finding algorithm
(Lawson et al. 1995) [4]	NA / 84 leads	False	NA	User intervention	NA	NA	Skelotinization
(J.T Wang and Mital 1996) [5]	NA	False	NA	User intervention	NA	Iterative Mask	Thinning Algorithm
(Mitra, Mitra and Chaudhuri 2004) [6]	NA	False	NA	User intervention	NA	User defined threshold	Pixel vertical extraction
(Badilini et al. 2005) [7]	University of Rochester Heart Research Follow-Up Program / 720 leads	False/True	NA	User intervention	NA	NA	Active Contour
(Chebil, Al-Nabulsi, and Al-Maitah 2008) [8]	NA / NA	False	NA	NA	NA	NA	Pixel vertical extraction
(Swamy, Jayaraman, and Chandra 2010) [9]	NA / 120 leads	False	NA	NA	Radon Transform	Otsu	Pixel vertical extraction
(Shi, Zheng and Dai 2011) [10]	NA / NA	False	NA	NA	NA	Sobel	Pixel k-mean clustering
(Sanromàn-Junquera et al. 2012) [11]	Hospital General Gregorio Maranon AND Hospital Universitario Virgen de la Arrixaca de Murcia / NA	False	NA	NA	Hough transform	NA	Pixel vertical extraction
(Kumar et al. 2012) [12]	MIT-BIH / NA	False	NA	User intervention	NA	User defined threshold	Pixel vertical extraction
(Jayaraman et al. 2012) [13]	NA / 300 leads	False	NA	NA	Radon transform	Otsu	Pixel vertical extraction
(Garg et al. 2012) [14]	NA / 240 leads	False	NA	NA	Hough transform	Color segmentation	Pixel vertical extraction
(Ravichandran et al. 2013) [15]	Emory Vietnam Twins Study / 638 leads	False	NA	User intervention	- User intervention	Otsu	Pixel vertical extraction
(Mallawaarachchi Perera and Nanayakkara 2014) [16]	NA / 216	False	NA	User intervention	- Radon Transform	Otsu	Pixel vertical extraction
(Patil and Karandikar 2015) [17]	NA / NA	False	NA	User intervention	NA	User defined threshold	Pixel vertical extraction
(Attin et al. 2016) [18]	NA / NA	False	NA	NA	NA	NA	Shortest Path
(Lozano-Fernandez et al.	NA / NA	False	True	User	Perspective	Color filtering	NA

Computer Methods and Programs in Biomedicine 221 (2022) 106890

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/cmpb

Digitizing ECG image: A new method and open-source software code

Julian D. Fortune[a], Natalie E. Coppa[a], Kazi T. Haq[b], Hetal Patel[b,c], Larisa G. Tereshchenko[b,d,*]

www.nature.com/scientificdata

SCIENTIFIC DATA

Check for updates

OPEN

DATA DESCRIPTOR

PTB-XL, a large publicly available electrocardiography dataset

Patrick Wagner[1,2,3,6], Nils Strodthoff[2,6], Ralf-Dieter Bousseljot[1], Dieter Kreiseler[1], Fatima I. Lunze[4], Wojciech Samek[2] & Tobias Schaeffter[1,3,5]✉

ECG Signal Analysis Using 2-D Image Classification with Convolutional Neural Network

Publisher: IEEE

Cite This

PDF

electronics

MDPI

Article

Multiclass ECG Signal Analysis Using Global Average-Based 2-D Convolutional Neural Network Modeling

Muhammad Wasimuddin [1], Khaled Elleithy [1], Abdelshakour Abuzneid [1], Miad Faezipour [1,2,*] and Omar Abuzaghleh [1]

RESEARCH ARTICLE

G2-ResNeXt: A Novel Model for ECG Signal Classification

SHENGNAN HAO[1], HANG XU[1], HONGYU JI[2], ZHIWU WANG[3], LI ZHAO[4], ZHANLIN JI[1,5], (Member, IEEE), AND IVAN GANCHEV[5,6,7], (Senior Member, IEEE)