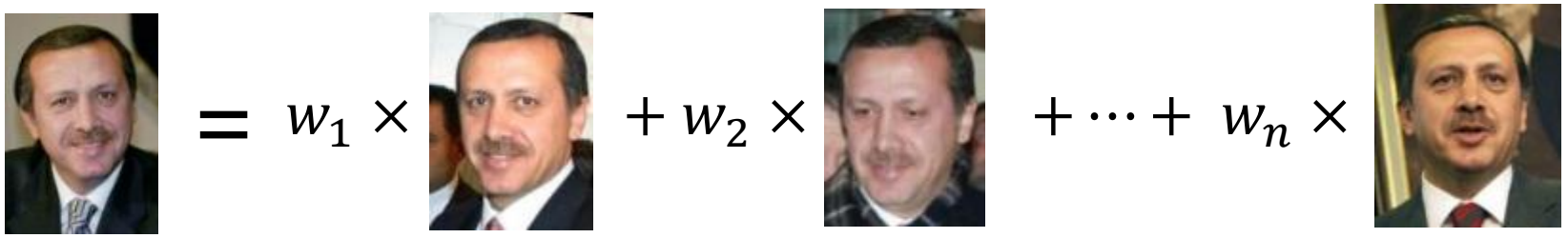
回归模型的应用

黄晟
重庆大学软件学院

基于线性回归的人脸识别

主要思想：一个样本可以被其他同类样本线性表示。



Naseem I, Togneri R, Bennamoun M. Linear regression for face recognition[J]. *IEEE Transactions on Pattern Analysis & Machine Intelligence*, 2010, 32(11):2106-2112.

Linear regression for face recognition

- 根据前面假设，我们可以利用一个线性方程来描绘这种线性关系：
  - $\tilde{x} \approx X_c \omega_c \in \mathcal{R}^{d \times 1}$, (1)
  - $X_c = [x_1, x_2, \cdots, x_m] \in \mathcal{R}^{d \times m}$
  - ω_c=$[w_1, w_2, \cdots, w_m] \in \mathcal{R}^{1 \times m}$
- $\tilde{x}$是输入测试样本，X_c是所有c类样本组成的样本矩阵，ω_c是X_c关于$\tilde{x}$的线性表示的系数。如果假设成立且输入样本属于c类样本，则
  - $c = \underset{i}{\operatorname{argmin}} ||\tilde{x} - X_i \omega_i||_2^2, i \in \{1,2, \cdots, c, \cdots, C\}$

Linear regression for face recognition

- 其他用于人脸识别的经典线性回归算法:
  - Sparse Representation (稀疏表示)[1]
  - Collaborative Representation (协同表示)[2]
- **假设调整：**与所有人脸样本线性相关，但同类样本在线性表示中贡献最大：

$$\tilde{x} \approx X\omega \in \mathcal{R}^{d\times 1},\ \tilde{X}_i \subset X,\ \tilde{\omega}_i \subset \omega$$

$$c = \underset{i}{\operatorname{argmin}} ||\tilde{x} - \tilde{X}_i\tilde{\omega}_i||_2^2, i \in \{1,2,\cdots,c,\cdots,C\}$$

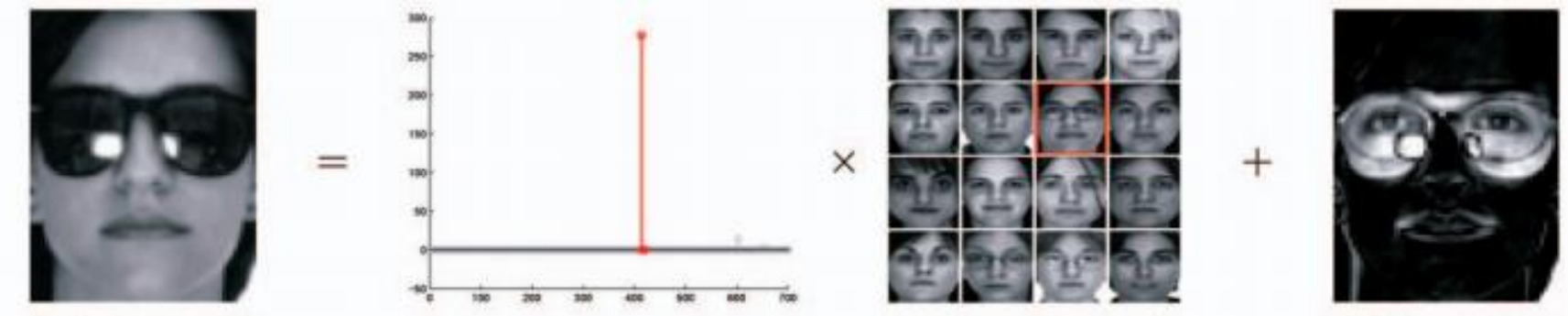
[1] Wright J, Yang A Y, Ganesh A, et al. Robust Face Recognition via Sparse Representation[J]. *IEEE Transactions on Pattern Analysis & Machine Intelligence*, 2008, 31(2):210-227. (引用：11572)

[2] Zhang L, Yang M, Feng X. Sparse representation or collaborative representation: Which helps face recognition?[C] // *IEEE International Conference on Computer Vision (ICCV)*, 2012:471-478. （引用：2353）

Sparse Representation

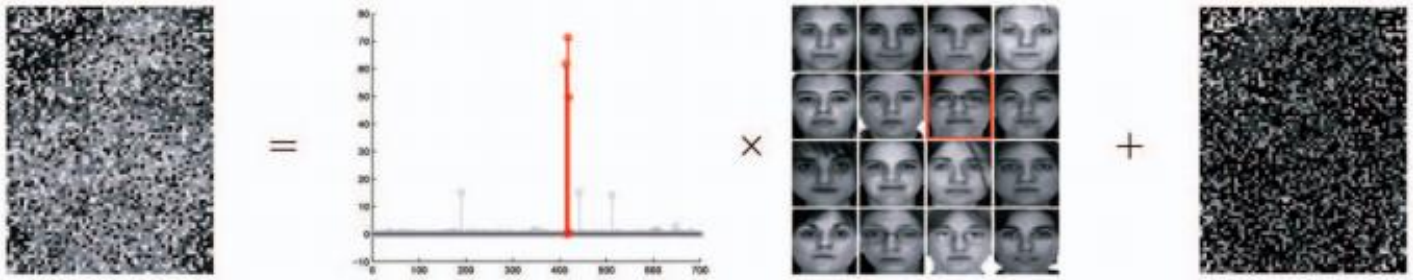
- 思想：
  - ① 强制选择极少数训练样本线性表示输入样本。
  - ② 被最终选择样本应与输入样本具有很强的关联性。
  - ③ 强调线性表示系数ω的稀疏性。

$$\min_{w} ||\tilde{x} - X\omega||_2^2 + \beta||\omega||_1$$

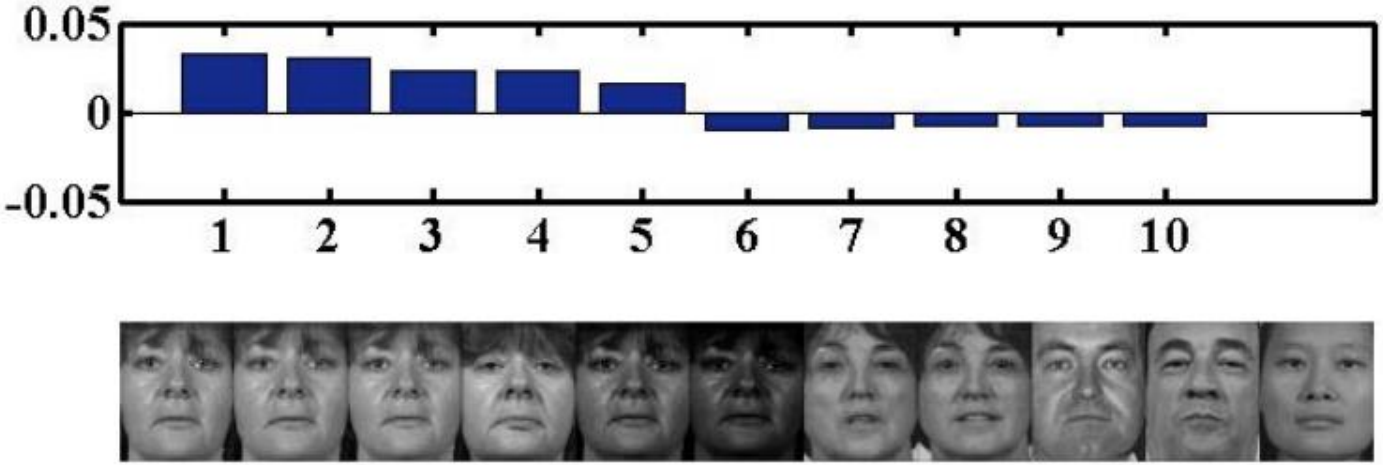


Sparse Representation

- 优点：
  - 对噪声和遮挡等影响因素比较鲁棒。



  - 极强的相关样本选择能力。



Collaborative Representation

- 稀疏表示的缺点：
  - 计算代价高
  - 假设过强，表示不够光滑(Representation is not smooth)，忽略其他样本的贡献。
- 解决思路：
  - 把1范数约束项进行松弛：

$$\min_{w} ||\tilde{x} - X\omega||_2^2 + \beta||\omega||_2^2$$

  - 典型的最小二乘问题，直接求解。
  - 协同表示的特性与稀疏表示相似，对噪声与遮挡也具有一定的鲁棒性

Evaluation of LR approaches

- 性能评估（2折交叉验证）：

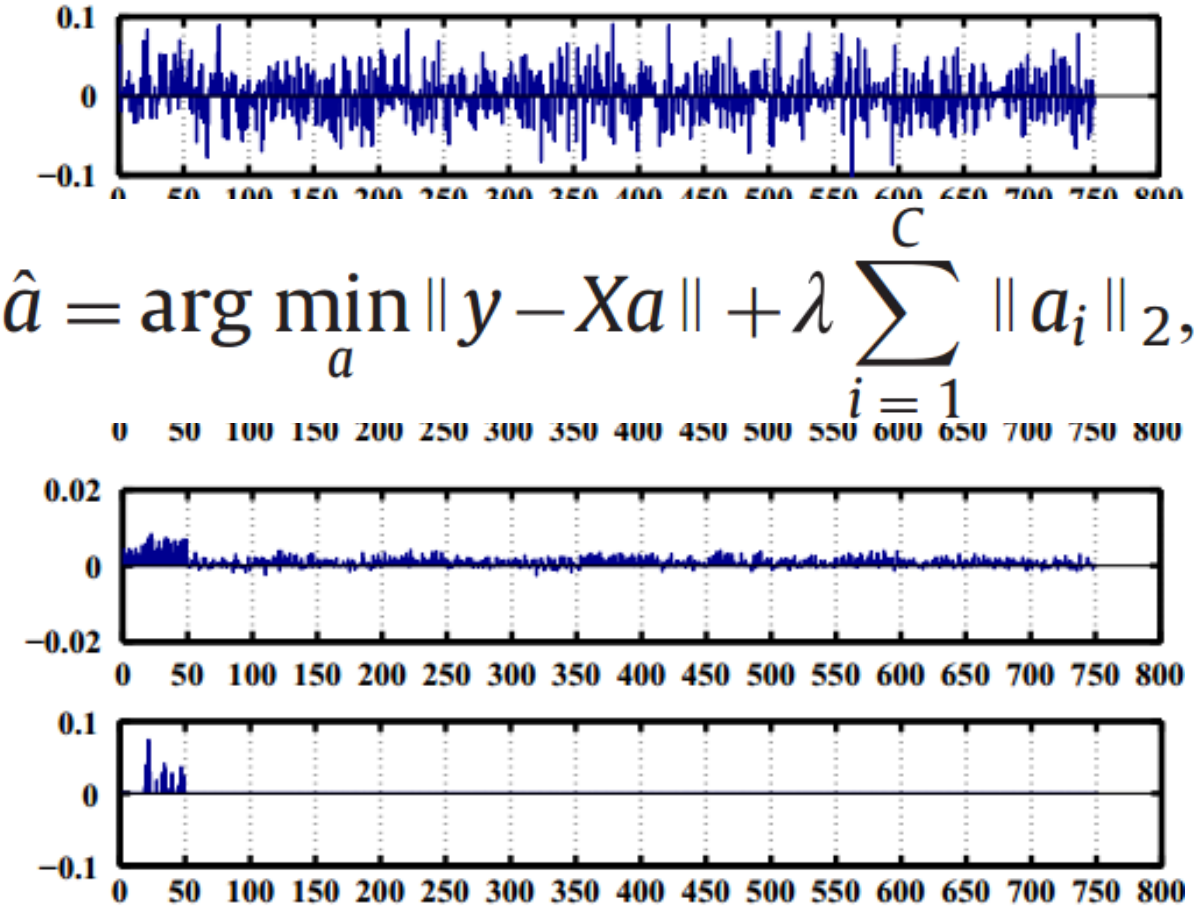
Table 1
Classification accuracy comparison on ORL, AR, Scene15 and Caltech256 databases.

Methods	Classification accuracy (Mean ± STD,%)				
	ORL	AR	Scene15	Caltech256	COIL20
NNC	87.25 ± 1.06	66.01 ± 0.08	61.47 ± 1.41	49.25 ± 1.23	84.51 ± 1.47
AHC [24]	88.21 ± 0.41	69.35 ± 0.25	74.49 ± 1.60	56.70 ± 2.14	**89.87 ± 1.41**
RFC [29]	88.53 ± 2.13	69.73 ± 0.88	72.27 ± 2.59	56.32 ± 3.00	88.11 ± 2.37
LIBSVM [30]	90.25 ± 3.18	68.10 ± 0.67	**74.60 ± 2.17**	60.85 ± 2.47	87.50 ± 1.18
LRC [21]	88.75 ± 3.18	68.75 ± 0.43	60.33 ± 3.30	43.00 ± 0.85	88.82 ± 1.08
SRC [2]	92.00 ± 3.54	63.87 ± 0.42	67.20 ± 1.13	48.05 ± 0.64	88.19 ± 0.98
SGC [31]	88.50 ± 2.83	73.27 ± 0.42	71.27 ± 2.17	50.60 ± 3.45	88.33 ± 0.59
CRC [12]	92.75 ± 3.89	68.25 ± 0.42	67.60 ± 3.58	50.06 ± 0.71	88.81 ± 1.10
CSSRC	**94.25 ± 3.18**	**77.14 ± 0.34**	**74.60 ± 2.36**	**61.15 ± 1.63**	89.17 ± 1.37

Huang, Sheng, Yu Yang, Dan Yang, Luwen Huangfu, and Xiaohong Zhang. "Class specific sparse representation for classification." *Signal Processing* 116 (2015): 38-42.

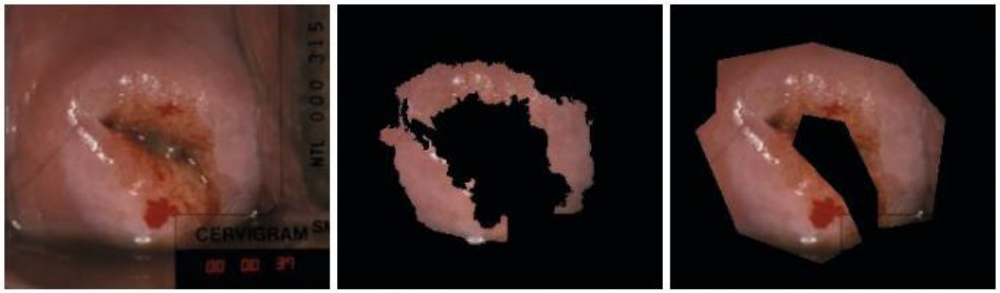
Observation from real data

- the regression coefficients of LR, SR, CR, CSSR(from top to down, the test sample belongs to the category of the first 50 training samples)

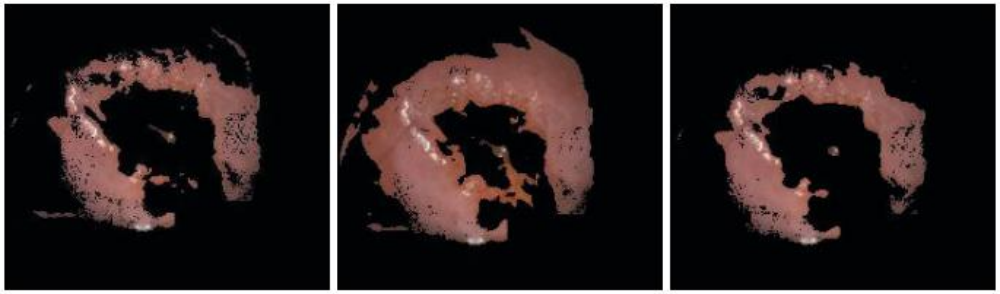


基于逻辑回归的医学图像分割

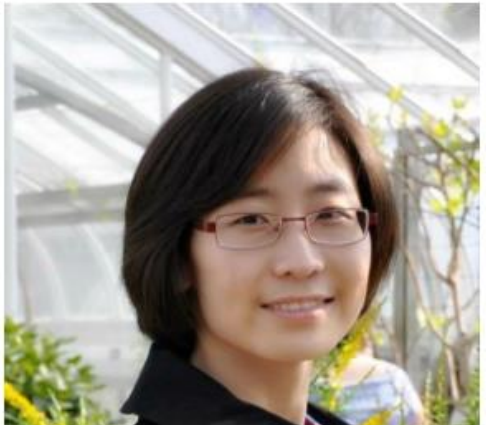
- Robust Logistic Regression (rLR) = Sparse Representation + Logistic Regression
- 图像分割问题=像素级分类问题



(a) Image for segmentation (b) The groundtruth (c) Roughly labeled data



(d) LR using groundtruth (e) LR (f) rLR



Mingchen Gao (高明辰)

Department of Computer Science and Engineering
University at Buffalo, SUNY

347 Davis Hall, Buffalo, NY, 14260
Phone: (716)-645-2834
Email: mgao8 at buffalo dot edu
Office Hours: Wed 2-4 pm

I am looking for motivated Ph.D. stude

Gao M, Huang J, Huang X, et al. Simplified labeling process for medical image segmentation[C]// ***International Conference on Medical Image Computing & Computer-assisted Intervention*** (MICCAI), 2012:387.

总结

- 重点掌握：
  - 线性回归
  - 逻辑回归
- 自学：
  - 《机器学习》中多分类学习章节
- 课后练习：
  - 实现线性回归，在ORL人脸数据库上利用2折交叉验证法评估线性回归人脸识别的性能。
  - 《机器学习》课后习题3.3
    - 编程实现对数几率回归，并给出西瓜数据集3.0α上的结果。