

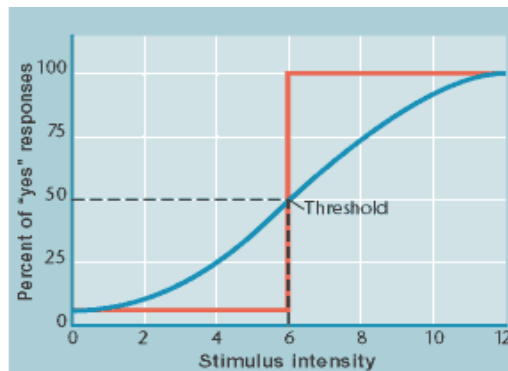
认知心理学基础

第二讲 感觉

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人工智能学院

感觉阈值

- **Absolute threshold (绝对阈限):**
 - The smallest intensity of a stimulus that must be present for a stimulus to be detected.
 - The least amount of energy that can be detected 50% of the time.

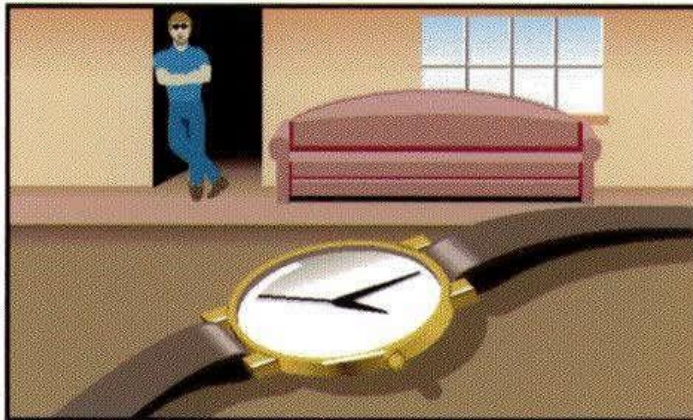


Absolute Threshold: Vision



A candle flame seen at 30 miles on a clear, dark night

Absolute Threshold: Hearing



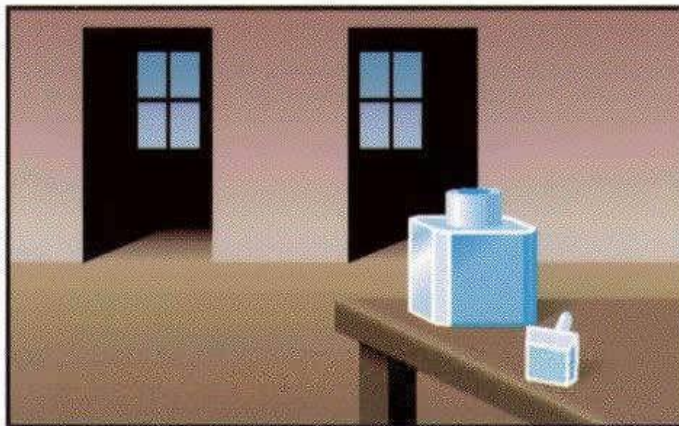
The tick of a watch under quiet conditions at 20 feet

Absolute Threshold: Taste



One teaspoon of sugar in 2 gallons of water

Absolute Threshold: Smell



One drop of perfume diffused into the entire volume of a 3-room apartment

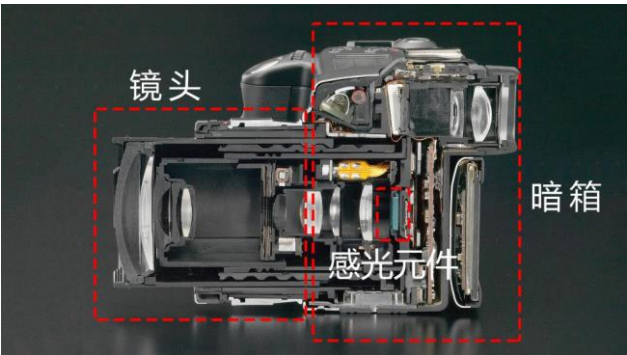
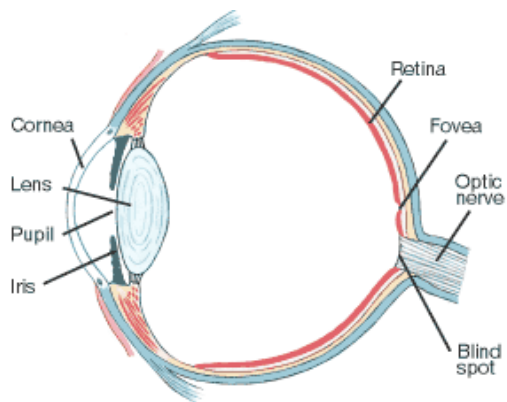


We can feel a bee's wing falling on our cheeks when it is dropped from a distance of one centimeter.

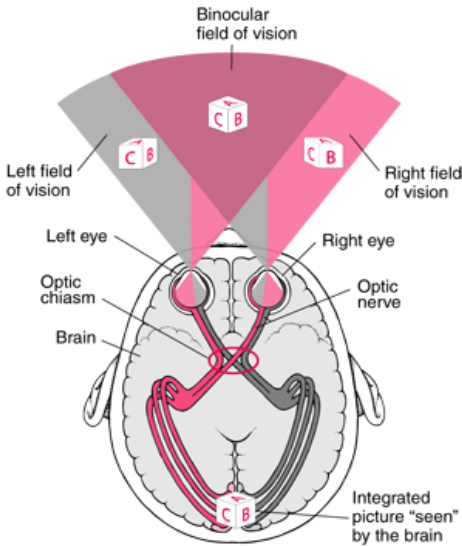
Sensory Adaptation (感觉适应)

- **Why chefs cook gets salty?**
- **Why can't you smell the fragrance when you smell a rose after a while?**
- 久在芝兰之室而不闻其香,久入鲍鱼之肆而不闻其臭
- **An adjustment in sensory capacity after prolonged exposure to unchanging stimuli.**
- In most cases, our senses adjust to the level of stimulation they are experiencing.
- The apparent decline in sensitivity is due to the inability of the sensory nerve receptors to fire off messages to the brain indefinitely.

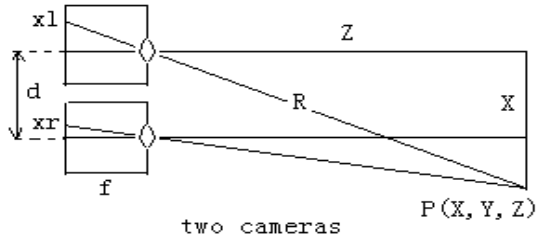
视觉系统的类比



为什么哺乳动物都进化为双目



双目立体视觉



$$\frac{x_l}{f} = \frac{X}{Z}$$

$$\frac{x_r}{f} = \frac{X - d}{Z}$$



$$Z = \frac{f \times d}{x_r - x_l}$$

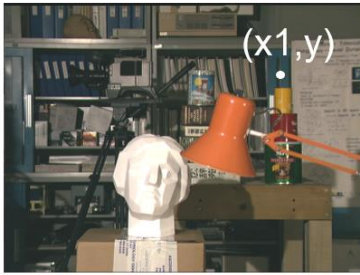
相似三角形1

相似三角形2

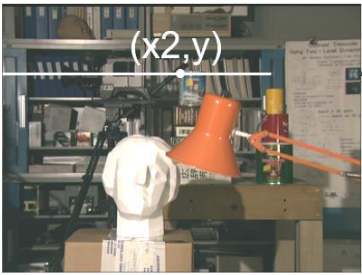
深度计算公式

双目立体视觉

左眼图像



右眼图像



深度图



视差 = $x_1 - x_2$ 与深度呈反比关系

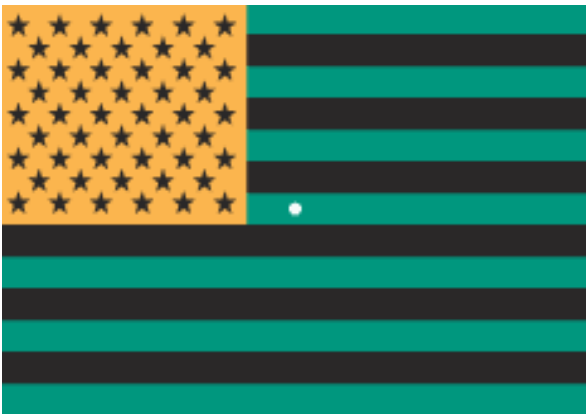
Check your blind spot

■ 闭上左眼，用右眼盯着图中的十字标记。现在把眼睛慢慢移近屏幕，移动时请继续注视十字标记。在某个距离处，斑点会消失（如果你移动得更近，它会再次出现）。斑点消失是因为它落在视神经头上，也就是盲点上



三色理论 (Ttichromatic theory of color)

- Young (1809) & Helmholtz (1824)
- 盯着这面旗帜上的白点凝视大约一分钟，然后看一张普通的白纸：你看到了什么？



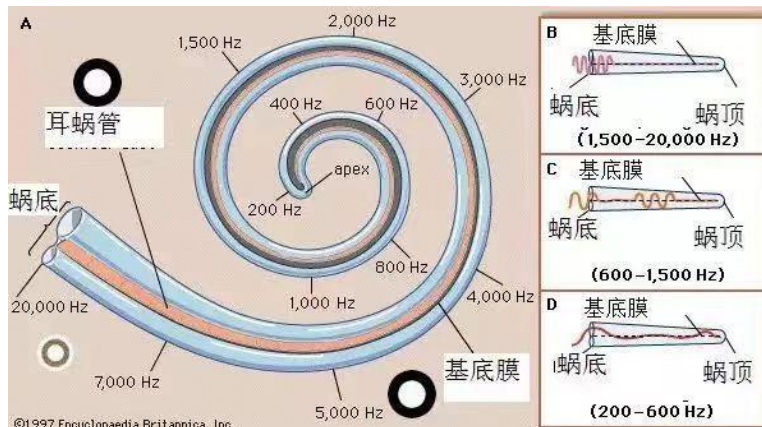
Opponent-process theory of color

■ 对立过程理论

- 三套颜色感受器：黄-蓝色、红-绿色、黑-白，非此即彼
- 虽然视网膜中有三种颜色受体，但它们传递的信息被视觉系统中的其他神经元编码为对手过程形式

听觉

- 人耳的听觉范围：16 ~ 20 000Hz
- Changes in pressure caused by molecules of air moving
- 位置理论：基底膜的不同区域对不同的频率有分离的反应



复指数信号

$$x(n) = C\alpha^n \quad \text{令 } C = |C|e^{j\theta} \quad \alpha = |\alpha|e^{j\omega_0} \quad \text{则}$$

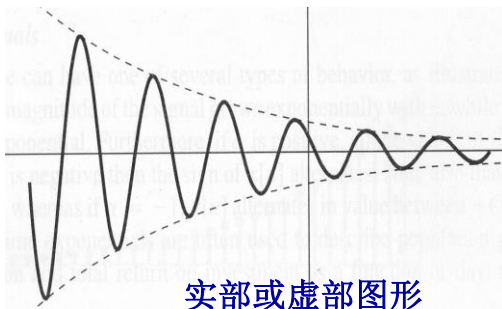
$$\begin{aligned} x(n) &= |C||\alpha|^n e^{j(\omega_0 n + \theta)} \\ &= |C| \cdot |\alpha|^n \cdot [\cos(\omega_0 n + \theta) + j \sin(\omega_0 n + \theta)] \end{aligned}$$

其实部与虚部都是幅度按实指数规律变化的正弦序列。

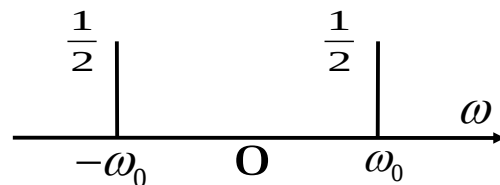
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傅里叶级数



$$\cos \omega_0 t = \frac{1}{2} (e^{j\omega_0 t} + e^{-j\omega_0 t}) \quad \text{表示为}$$

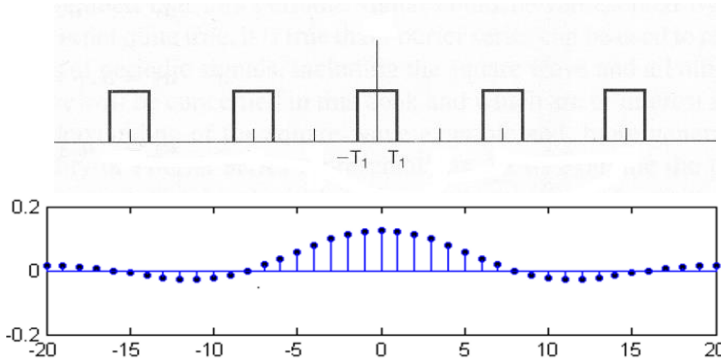


傅里叶分析要回答的一个本质问题——“是否任何周期信号都可以用一组成谐波关系的正弦信号的加权和来表示？”

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连续时间信号的傅里叶级数

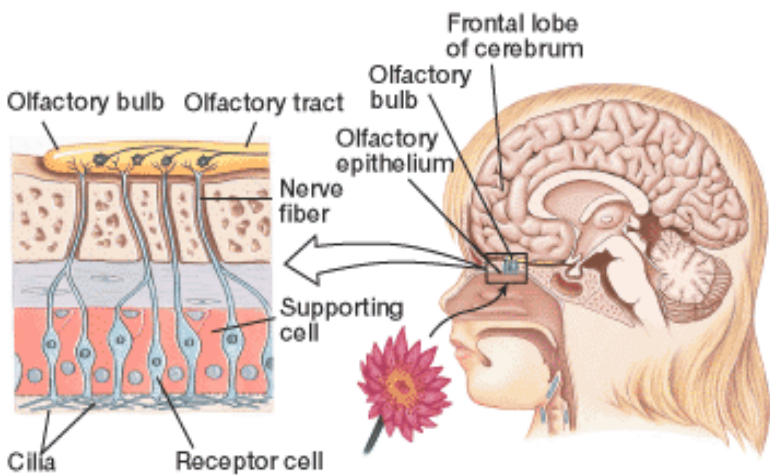


$$x(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$$

$$a_k = \frac{1}{T_0} \int_{T_0} x(t) e^{-jk\omega_0 t} dt$$

频谱图其实就是将时域信号随频率的分布表示出来。由于信号的频谱完全代表了信号，研究频谱就等于研究信号本身，这种方法称为**频域表示法**

嗅觉 (olfaction)



嗅觉与人工智能

- 受哺乳动物嗅觉系统的启发，英特尔神经形态计算实验室的 Nabil Imam 等在《自然-机器智能》发表论文，报告了一种设计用来模拟生物嗅觉的神经算法，这项成果有助于未来在智能应用中训练人工鼻子，在未知背景气味的情景下识别特定气味
- 利用甲苯、氨、丙酮、一氧化碳和甲烷等，对其进行气味训练，即使在强烈背景干扰物的情况下也能识别它们

nature
machine intelligence

Article | Published: 16 March 2020

Rapid online learning and robust recall in a neuromorphic olfactory circuit

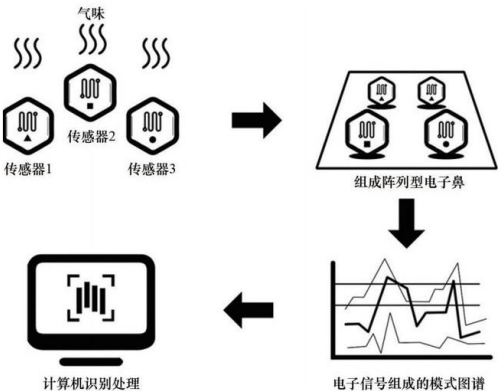
Nabil Imam & Thomas A. Cleland

Nature Machine Intelligence 2, 181–191(2020) | Cite this article

51 Altmetric | Metrics

嗅觉与人工智能

- 清华大学未来实验室徐迎庆教授在嗅觉计算硬件开发方面，完成了“嗅豆”系列电子鼻和采集装置的开发工作。目前已完成嗅豆1代/2代、嗅豆mini电子鼻的原型开发



触觉

■The skin senses

- Skin senses: The senses of touch, pressure, temperature, and pain
- All our skin senses play critical role in survival, making us aware of potential danger to our bodies

触觉与人工智能

- 复旦大学与新加坡南洋理工大学研究者们设计并开发了一种基于忆阻阵列的近传感模拟计算智能触觉感知系统，可用于假肢、可穿戴设备和机器人等人工智能感知系统

ADVANCED MATERIALS

Research Article | [Full Access](#)

Tactile Near-Sensor Analogue Computing for Ultrafast Responsive Artificial Skin

Ming Wang, Jiaqi Tu, Zhangcheng Huang, Ting Wang, Zhihua Liu, Feilong Zhang, Wenlong Li, Ke H Liang Pan, Xumeng Zhang, Xue Feng, Qi Liu, Ming Liu, Xiaodong Chen

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