Lecture 2 Image Formation

COMP3204 & COMP6223 Computer Vision

What is inside an image?

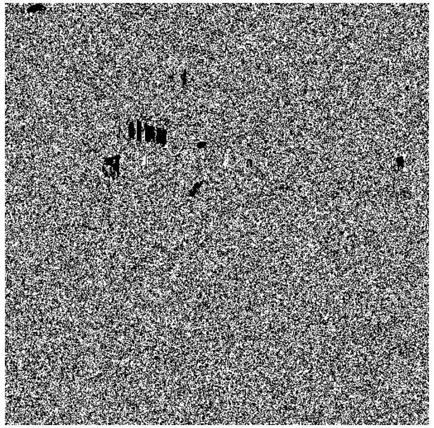
Book pp 37-45

Department of Electronics and Computer Science

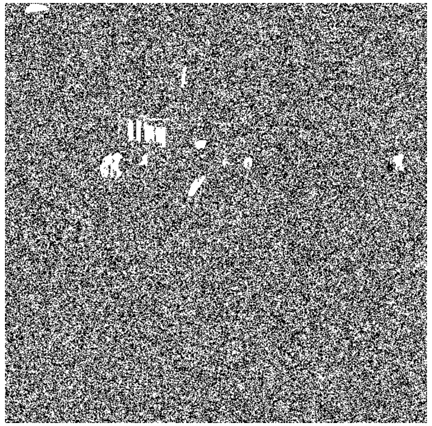
UNIVERSITY OF Southampton
School of Electronics and Computer Science

Decomposing an image into its bits

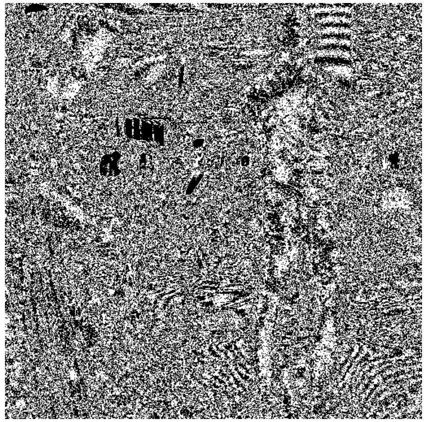
(a) original image



(b) bit 0 (LSB)

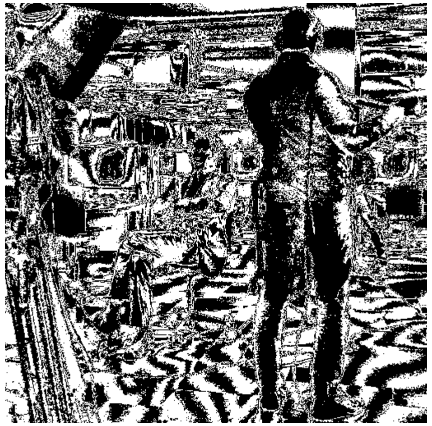


(c) bit 1

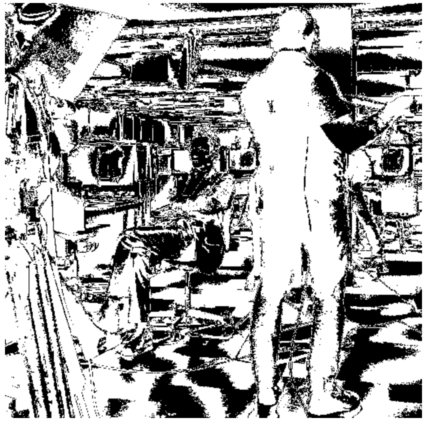


(d) bit 2

(e) bit 3



(f) bit 4



(g) bit 5

(h) bit 6

(i) bit 7 (MSB)

Effects of differing image resolution

(a) 64×64 **(b)** 128×128 **(c)** 256×256

Jean Baptiste Joseph Fourier

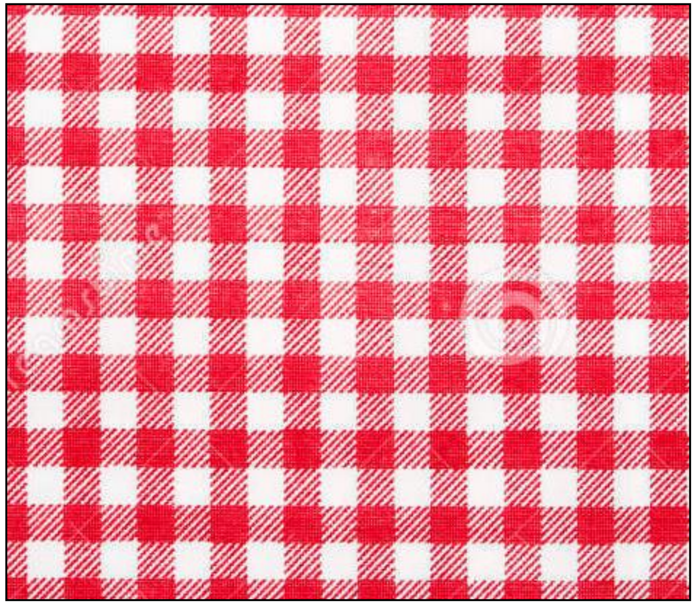
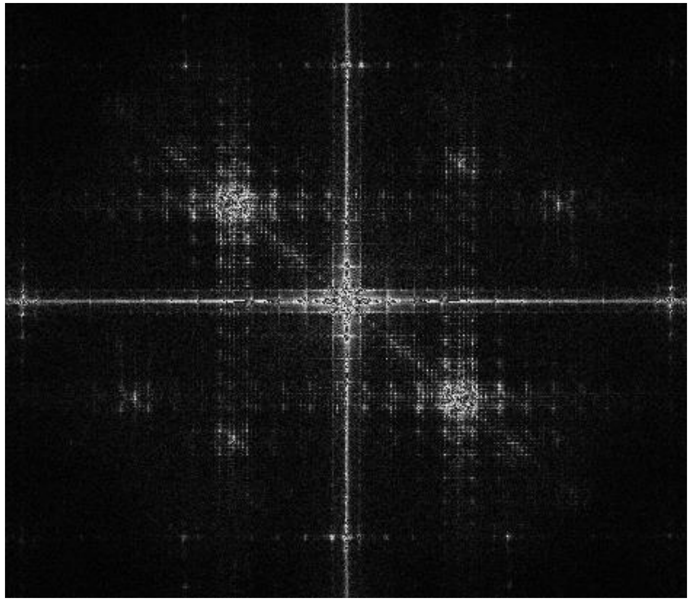
- Any periodic function is the result of adding up sine and cosine waves of different frequencies
- Sceptical? Yeah, so were Lagrange and Laplace. Good company eh?
- “Fourier’s treatise is one of the very few scientific books that can never be rendered antiquated by the progress of science” James Clerk Maxwell 1878
- Fourier 10 Laplace 0 …

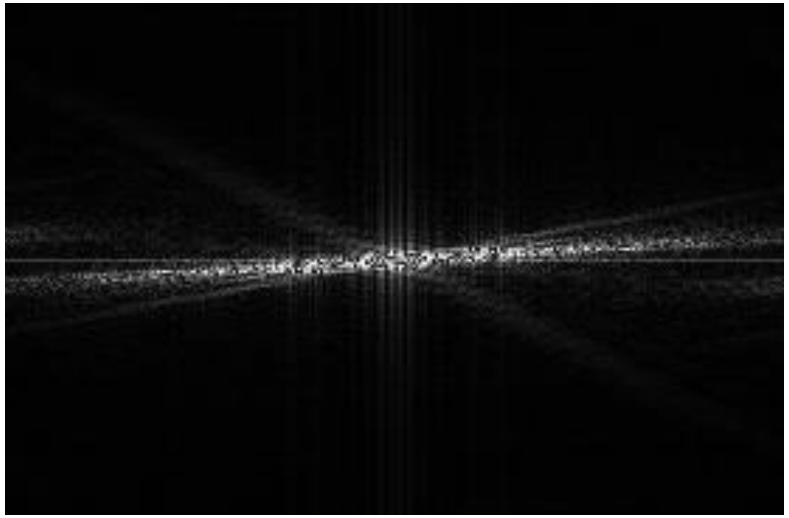
What are 2D waves?

2D waves are along x and y axes simultaneously

and in terms of frequency

- N.b. colour immaterial (just for visuals)



Step up Monsieur Fourier…

$$Fp(\omega) = \Im\left(p(t)\right) = \int_{-\infty}^{\infty} p(t)e^{-j\omega t}\,dt$$

where: $Fp\,(\omega)$ is the Fourier transform, and $\Im$ denotes the Fourier transform process;

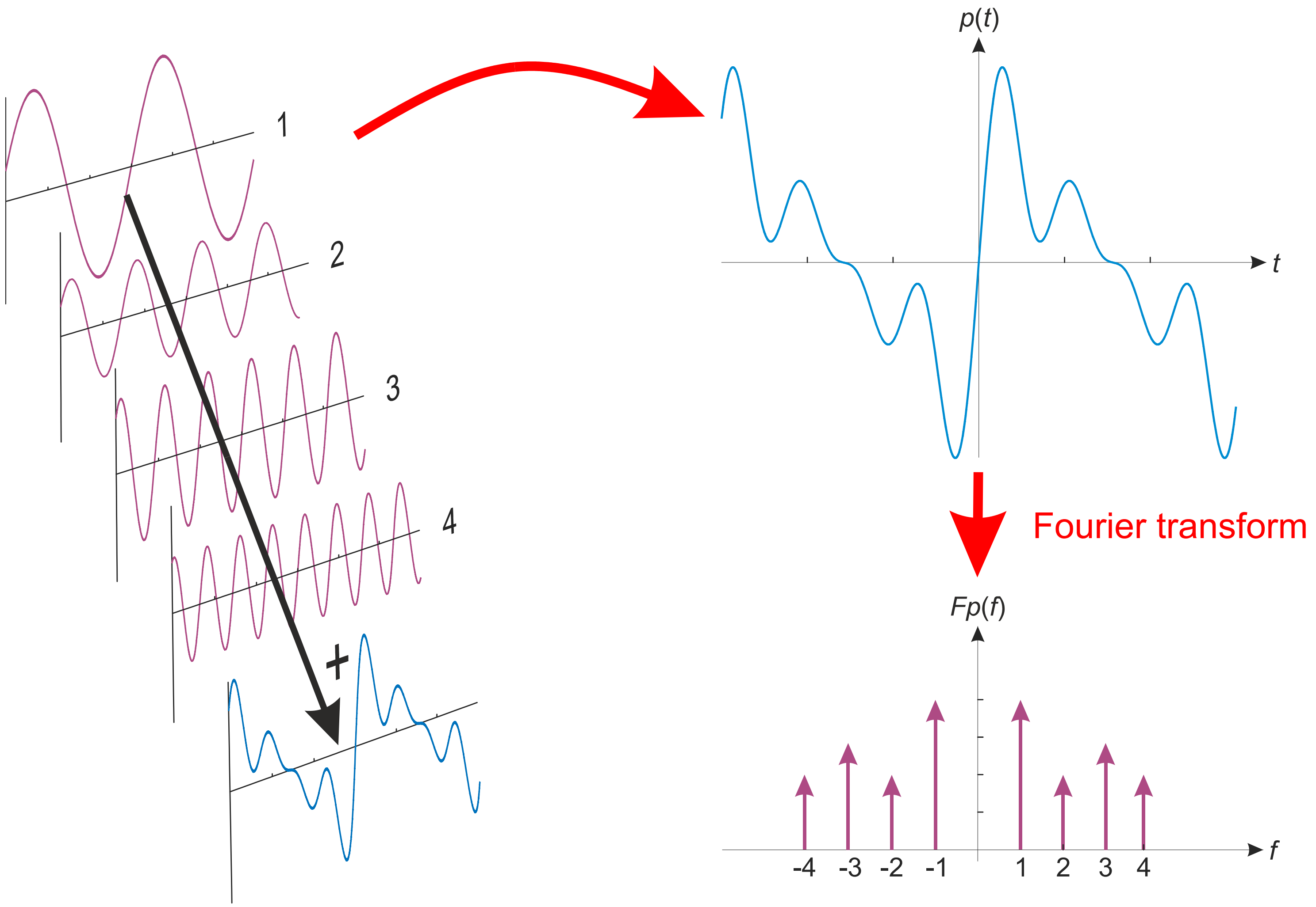
ω is the **angular** frequency, $\omega = 2\pi f$ measured in **radians/s** (where the frequency f is the reciprocal of time t, $f = 1/t$);

j is the complex variable $j = \sqrt{-1}$ (electronic engineers prefer j to i since they cannot confuse it with the symbol for current; perhaps they don't want to be mistaken for mathematicians who use $i = \sqrt{-1}$)

$p(t)$ is a **continuous** signal (varying continuously with time); and

$e^{-j\omega t} = \cos(\omega t) - j\sin(\omega t)$ gives the frequency components in $p(t)$.

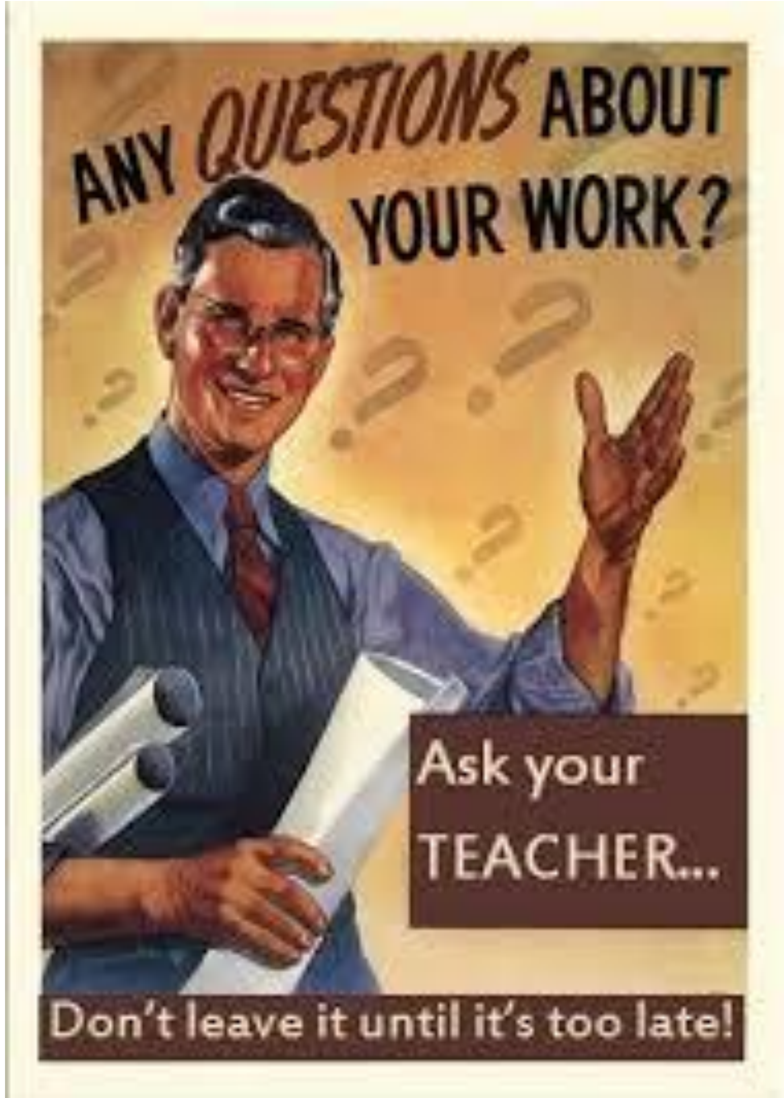
What does the Fourier transform do?

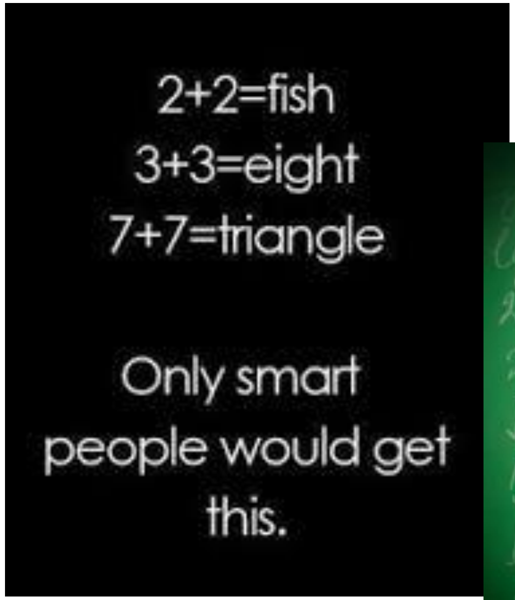


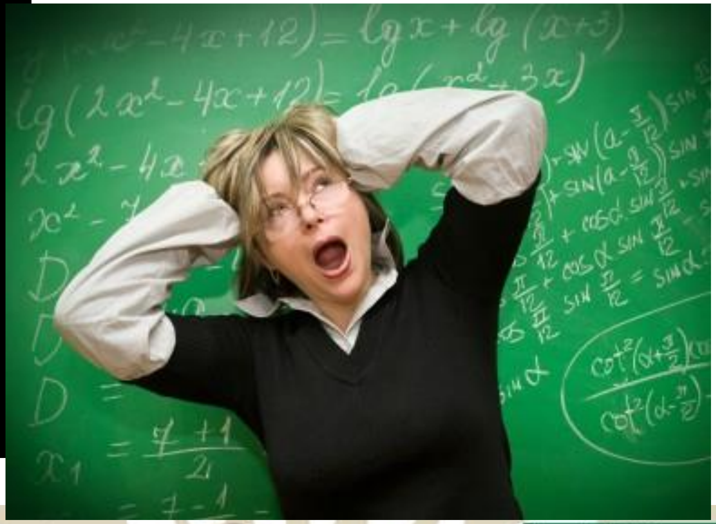
Zut alors! On doit applique ca

- Pulse $$p(t) = \begin{cases} A & \text{if} \quad -T/2 \le t \le T/2 \\ 0 & \text{otherwise} \end{cases}$$
- Use Fourier $$Fp(\omega) = \int_{-T/2}^{T/2} Ae^{-j\omega t}\, dt$$
- Evaluate integral $$Fp(\omega) = -\frac{Ae^{-j\omega T/2} - Ae^{j\omega T/2}}{j\omega}$$
- And get result $$Fp(\omega) = \begin{cases} \dfrac{2A}{\omega} \sin\left(\dfrac{\omega T}{2}\right) & \text{if} \quad \omega \ne 0 \\ AT \quad \text{if} \quad \omega = 0 \end{cases}$$

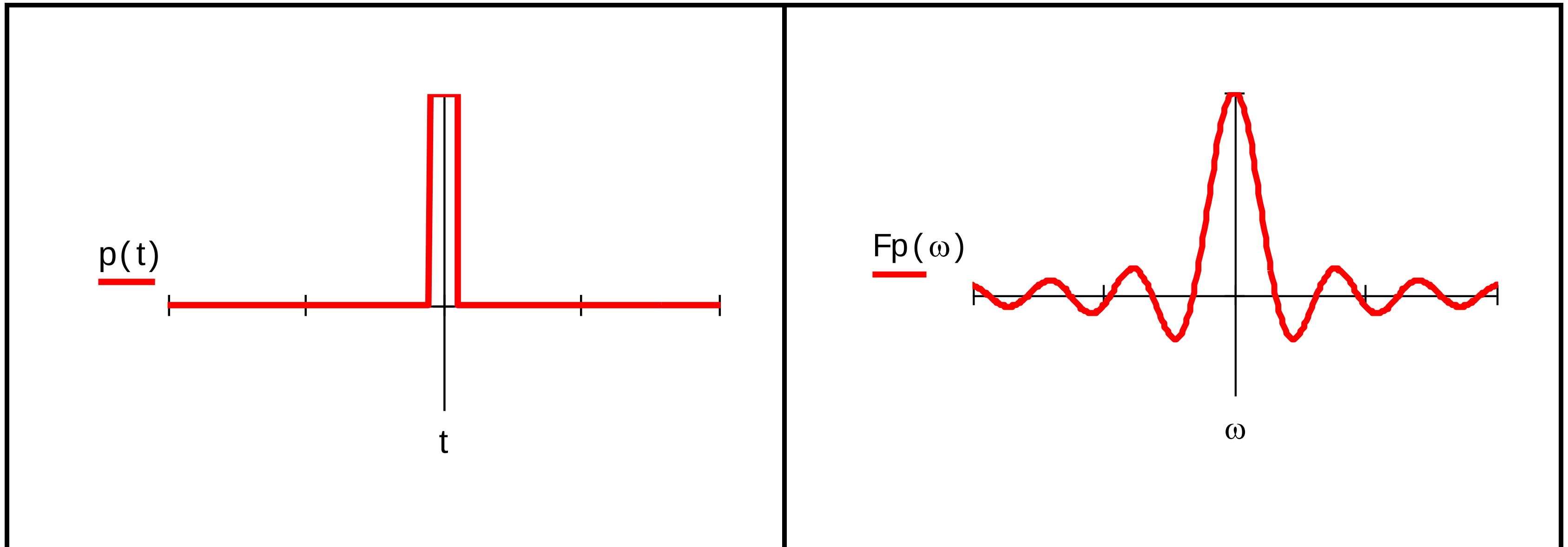
Google “are you frightened of maths”





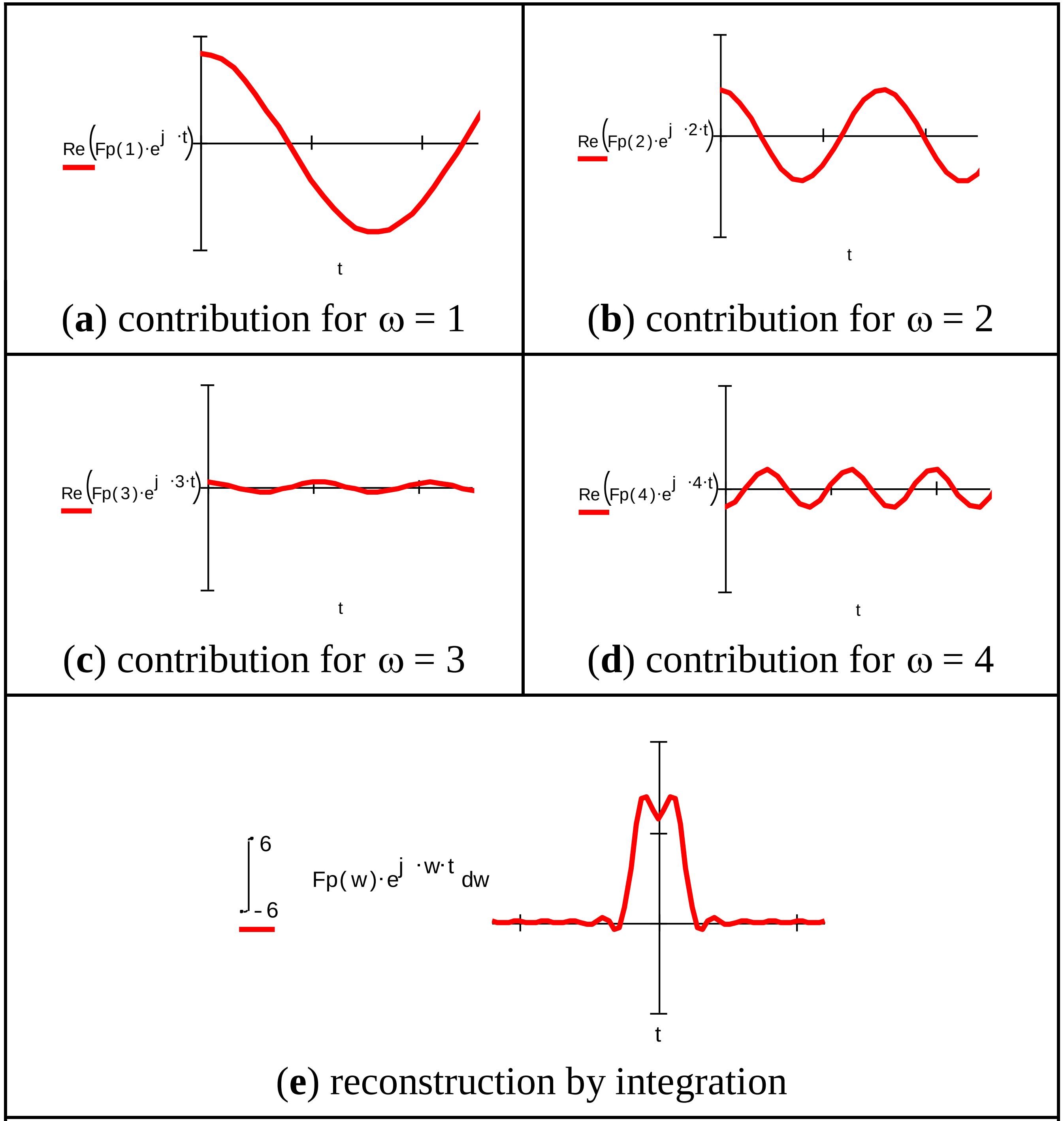


A pulse and its Fourier transform



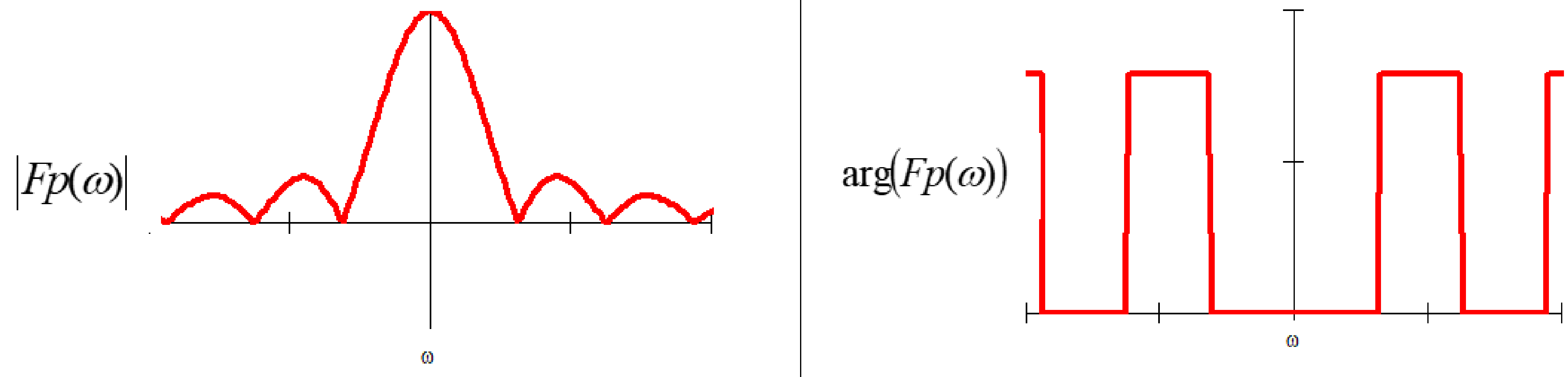
(a) pulse of amplitude *A* = 1 **(b)** Fourier transform

Reconstructing a signal from its Fourier transform



Magnitude and phase of Fourier transform of a pulse

$$Fp(\omega) = \int_{-\infty}^{\infty} p(t)e^{-j\omega t}dt = \mathrm{Re}\left(Fp(\omega)\right) + j\,\mathrm{Im}\left(Fp(\omega)\right)$$



(a) magnitude **(b)** phase

$$|Fp(\omega)| = \sqrt{\mathrm{Re}\left(Fp(\omega)\right)^2 + \mathrm{Im}\left(Fp(\omega)\right)^2}$$

$$\arg\left(Fp(\omega)\right) = \tan^{-1}\left(\frac{\mathrm{Im}\left(Fp(\omega)\right)}{\mathrm{Re}\left(Fp(\omega)\right)}\right)$$

Using Gait as a Biometric, via Phase-Weighted Magnitude Spectra

David Cunado, Mark S. Nixon and John N. Carter

Department of Electronics and Computer Science, University of Southampton, Highfield, Southampton SO17 1BJ, England.
Email: dc95r@ecs.soton.ac.uk and msn@ecs.soton.ac.uk

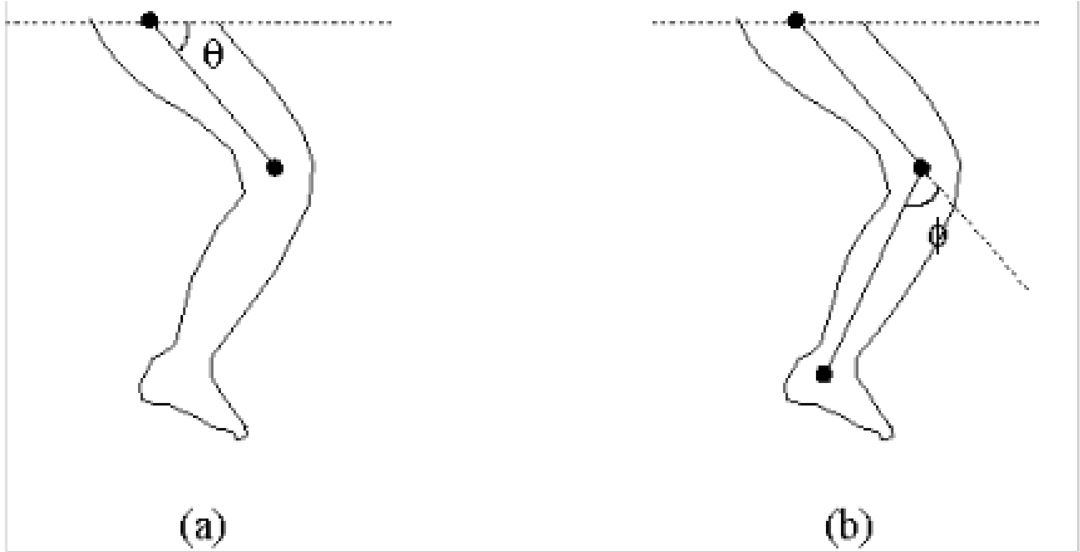


Fig. 1. (a) Hip and (b) Knee rotation angles.

http://eprints.soton.ac.uk/250040/1/cunado_avbpa.pdf

Gait patterns (angle of swinging leg)

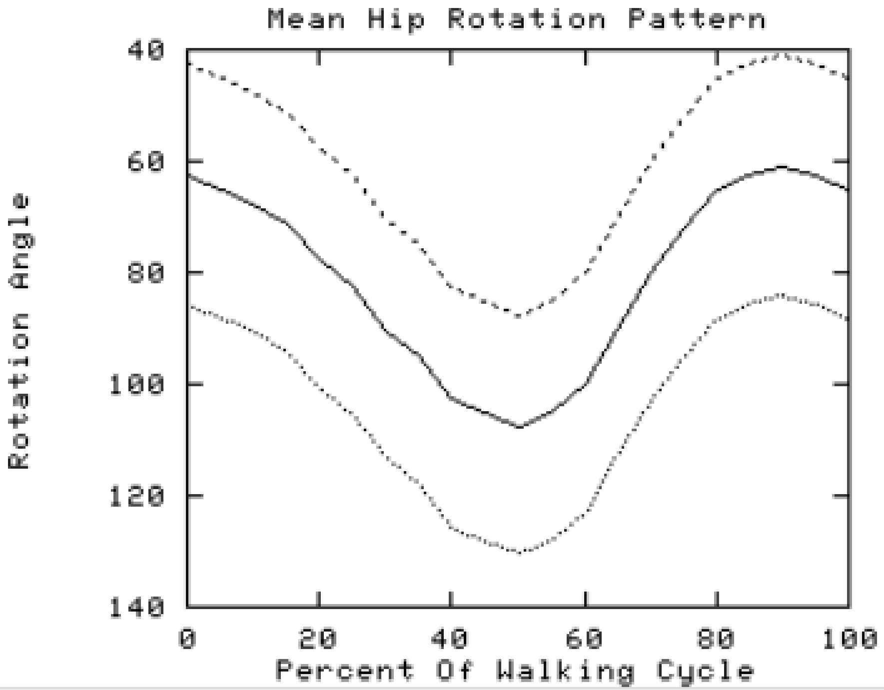
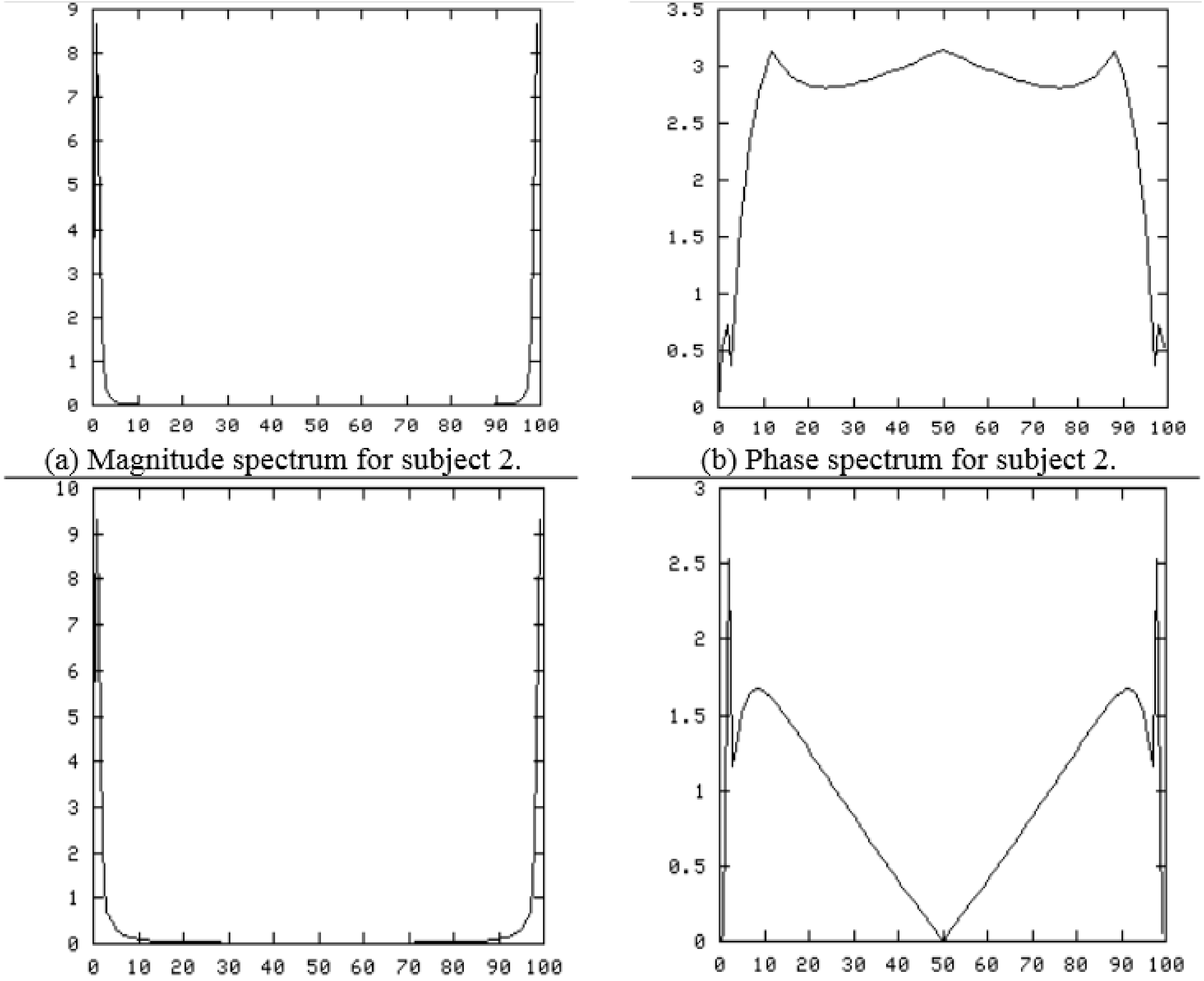


Fig. 2. Variation in Hip Rotation.

Fig. 3. Example Image of Walking Subject.

Gait magnitude and phase



(a) Magnitude spectrum for subject 2.

(b) Phase spectrum for subject 2.

(c) Magnitude spectrum for subject 5.

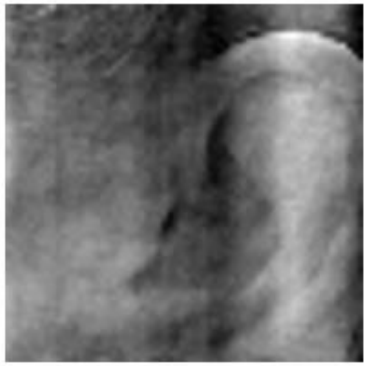
(d) Phase spectrum for subject 5.

Fig. 6. Phase and Magnitude Gait Spectra.

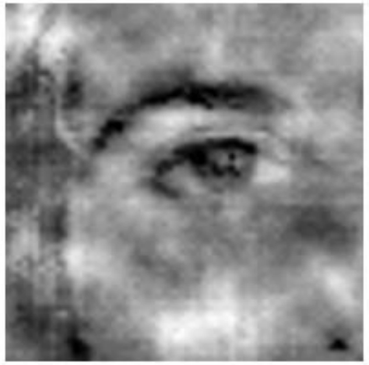
Illustrating the importance of phase

(a) eye image

(b) ear image



(c) reconstruction from magnitude(eye) and phase(ear)



(d) reconstruction from magnitude(ear) and phase(eye)