1. Objective:  
   reduce dimensionality of pattern space, yet maintain discriminator power for classification and invariant description in context of ear biometrics
2. Approaches:
   1. Brute Force:  
      Each pixel is transformed using the Energy & Force equations
   2. Frequency Domain Analysis: Fourier Transform etc. and then equations applied
3. Two stages:
   1. Image to force field transformation
   2. and potential well and channel extraction
4. Transform Assumption (for mathematical convenience):  
   Each pixel exerts an isotropic force on all the other pixels (they represent attractive particles, that act as the source of a spherically symmetric force field) that is proportional to pixel intensity and inversely proportional to the square of the distance, i.e. the inverse square law
5. Method
   1. Force field –> potential energy surface: comparable to mountain with peaks and ridges, where peaks = potential energy wells (sources) and ridges = energy channels, that lead to the wells (picture 2)
      1. Image scaling or initialisation (picture 1) position translation invariant
      2. Very tolerant of noise due to its inherent averaging
   2. The image contains an array of N attracting particles that exert a force F\_i(r\_j) of unit intensity at the pixel location with position vector r\_j by any other pixel pos.vec. r\_i and pixel intensity P(r\_i)  
      The sum over all other pixels j != i gives the force that vector r\_j exerts overall in the image, in other words, the force field that is generated by pixel r\_j
   3. Following: Magnitude of force <- inverse square law and a vector direction for the force
   4. Calculating the potential energy fields for each pixel to find the overlapping potential energy functions of all the image pixels for that specific pixel location which is repeated for all pixels in the image to generate a **potential energy surface** (represents the amount of energy that is exerted on a pixel if it moved around, like in physics … ) (picture 4)
   5. To discover the force field lines: generate an array of unit value mobile test pixels arranged in a closed loop surrounding the ear, which are then solely being ‘pulled’ by the force (gravity) fields of the ear’s pixels vectors so that their trajectory form the field line until they reached an extremum in the potential energy surface:   
      gradient is zero and no further force is exerted = no more movement   
      (picture 1, 2 & 3)
6. Advantages:
   1. Simplified implementation in time domain
   2. Time complexity reduced due to working in frequency domain: O(n \* log(n))
   3. Impervious to distortion in image due to motion
   4. Finds application in edge detection
   5. Higher efficiency (99.2%) as compared to other techniques
7. Disadvantages:
   1. At times, transform generates only one ‘well’ (source, origin)
   2. High computational costs for brute-force method: O(n²)
   3. Not widely applicable
   4. Occlusion by hair



