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Application of Calculus in Life Science

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Abstract

In this paper we are going to familion with the calculation and derive the general Euler Lagrange's equation for functional that deperid on function of one variable. We have the calculation of variation has traditionally applied in solving the problem of Mechabier we apply in biology by means of minime surface we familiar with the idea of using space curves to model protein structure and at the last we conclude the free energy associated with these staccoives by deriving two Euler- Lagvargel equation debena on curvature .

Introduction

Calcalms A variation

Calculms of variation help to formulate Geodesic problems on a plane sphere. There are many laws of physics which are Written as variable principles. The principle of last action is equivalent to Newton Second law of motion in mechanical System It leads naturally formulation of mechanics. It is hugely important topic on the Life science.

E [t] = $\int_a^b f$ (t, y(t), y'(t))dt

Where the integrand F[t, y(t), y' (t)] is a function of the independent variable t a function y(t) and the first derivative y'(t) with prime motation denoting the derivative with respect to t. The function y(t) is on D, the space of all c' function defrnedon the [a,b] with yla A and ylb) = B for any y(t)ED

Euler - Lagrange equation

Let ep, be the space of c² Curnes x: [0,1]→R" with x (0)=f and x(1)= Q. Let L:R^{2n+1} - R be a Sufficiently differentiable function and let us consider the functional S. ePQ – R

defined by

S [x] = $\int_6^1 L$ (x(t), x'(t))dt

The function L is called the Lagrangian and the functional S is called the action Ext remising S all yield a deferential equation for Recall that a path x is a Critical point for the action if for all endpoint - fixed Variations E , we have

$\frac{d}{ds}$ S [x+se] = 0

S=0

Differentially under the integral

Sign, we find

0 = $\int_0^1 \frac{dl}{dx}$ (x + s∈, t)dt s=0

= $\int_0^1 (\sum_{i=1}^{n} \frac{dl}{dxi} \frac{\text{dlei}}{\text{dxi}})$ dt

= $\int_0^1 (\sum_{i=1}^{n} \frac{dl}{dxi} - \frac{\text{d}}{\text{dt}} \frac{\text{dl}}{\text{dxi}}) \in i\ dt$

= $\int_0^1 . \sum_{i=1}^{n} (\frac{dl}{dxi} - \frac{\text{d}}{\text{dt}} \frac{\text{dl}}{\text{dxi}}) \in i\ dt$

Where we have integrated by parts and used that $\in (0) = \in (1)$

Using the fundamental lemma

This is equivalent to $\frac{\text{d}}{\text{dx2}} - \frac{\text{d}}{\text{dt}} \frac{\text{dl}}{\text{dx2}}$

For all I = 1,2,……….n

This is the Euler-Lagrangs equation

* Minimal surface

Minimal Surfaced are defied as Surface with 280 mean Curvature Minimal Surface may also be Chamotorized as surface of minimal surface area for given boondy Condition.

A plane is a trivial minimal Surface and the first non-trivial examples (the Catenoid and helicoid) where founded by me usnier in 1776-

A Surface can be parameterized using an isothermal parameterization. The term minimal Surface is used because these surface Originally areas as Surfaces that minimized total surface area subject to some Constraints.

Figure 3.4: A soap film of a helicoid. Image courtesy of http://www.math.cornell.edu/~mec/Summer2009/Fok/index.html

quaternary

* Regular Secondary Structure of protein.

Protein Secondary Structure is the local Spatial Confirsonation of the polypeptide back bone excluding the Side Chains. The two most common Secondary Structure elements are alpha helecs and beta sheet Though beta turns and omega loop occur as well Secondary structure elements typically Spon tanearsly form an instrudiate before the protein folds intoits. There dimensional tertiary Structure.

Secondary Structure is formally detained by the pattern of hydrogen bonds between. The mine hydrogen and Carboxyl oxygen. Atoms in the peptides backbone Secondary structure may alternately be defined based on the regular pattern of back bone dihedral angles in a particular region of the Ramchandaran plot regard less of whether it has the Correct hydrogen bonds. The concept of secondary structure was first in structured by

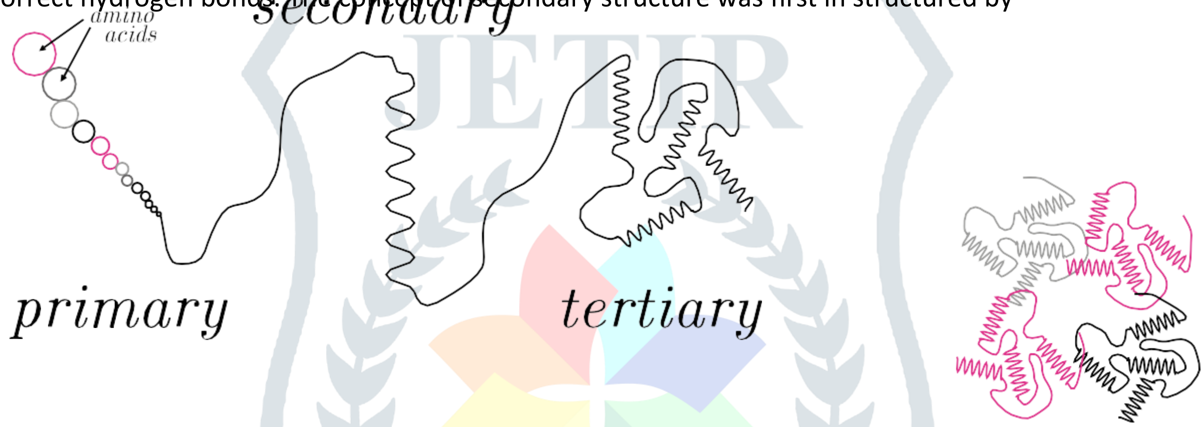


figure 3.1: A good way to think about protein structure is to imagine zooming out at each step as you move from primary to quaternary.

Geo desice on hele conder.

A geodesic on a Helicorindes is a come that follows the shortest pata between two pants on the Surface of the Helicoides. It con also be described as a Cume that is locally straight and geodesic curvilinear

Minimal surface

We have

S[J] = $\iint F$ (x,y,g g_x , g_y)dxdy

$\iint . \sqrt{1+gx^2+gy\text{^}2}$ dxdy

Among ad miscible surface

Z= g(x,ythe a)

The associated Euler- Lagrange equation is

$\frac{\partial f}{\partial g} - \frac{d}{dx}\frac{\partial f}{\partial gx} - \frac{d}{dy}\frac{\partial f}{\partial gy}$ =0

We have F does not depend explicitly on g , so the abonesimpli fier to

$\frac{d}{dx}\frac{of}{\partial gx} + \frac{d}{\partial y}\frac{of}{\partial gy}$ =0

Company the appropriated partial derivatives , plugging them into gn

$$\frac{d}{dx}\left[\frac{g_x}{\sqrt{1+g_x^2+g_y^2}}\right] + \frac{d}{dy}\left[\frac{g_y}{\sqrt{1+g_x^2+g_y^2}}\right] = 0$$

$$\frac{g_{xx}\sqrt{1+g_x^2+g_y^2} - g_x\left[\frac{g_x g_{xx}+g_y g_{xy}}{\sqrt{1+g_x^2+g_y^2}}\right] + g_{yy}\sqrt{1+g_x^2+g_y^2} - g_y\left[\frac{g_x g_{xy}+g_y g_{yy}}{\sqrt{1+g_x^2+g_y^2}}\right]}{1+g_x^2+g_y^2} = 0$$

$$\frac{g_{xx}(1+g_x^2+g_y^2) - g_x^2 g_{xx} - g_x g_y g_{xy} + g_{yy}(1+g_x^2+g_y^2) - g_x g_y g_{xy} - g_y^2 g_{yy}}{\sqrt{1+g_x^2+g_y^2}} = 0$$

$$(1+g_y^2)g_{xx} - 2g_x g_y g_{xy} + (1+g_x^2)g_{yy} = 0,$$

which is the Minimal Surface Equation for the graph g.

The helicoids

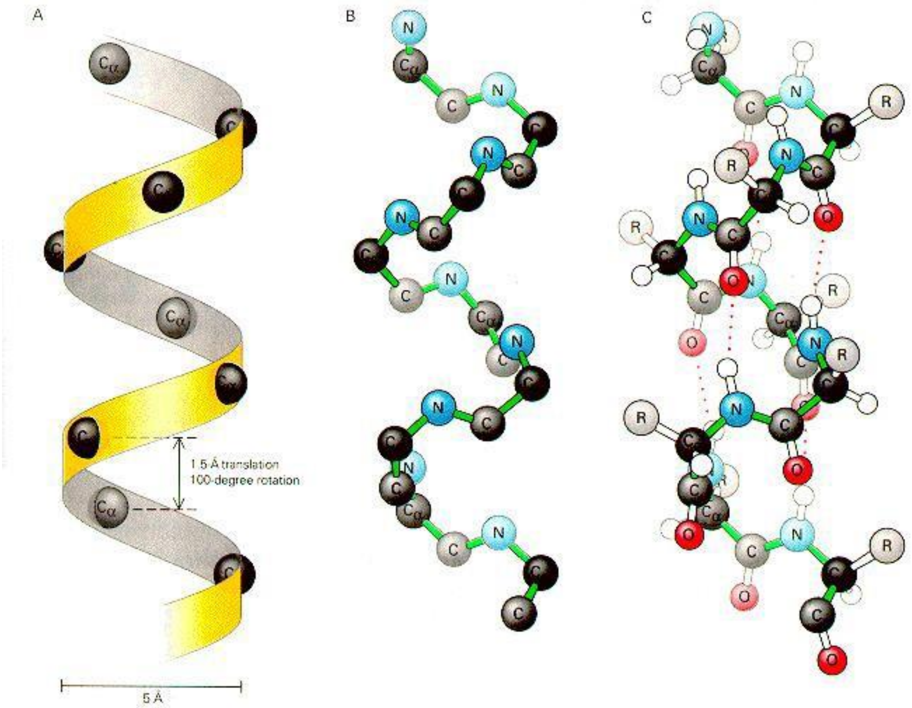
Let as consrdiv one parameterization

$\bar{x}$ (u,v)= (-b sin hv sin u, b sin hv sin v, bu)

Where b∈ R is an arbitrary constant the lengent vectors associated with this parameterization of the heli coud are

$\bar{x}$ (u,v)= (-b sin hv cos u- b sin hv sin v)

$\bar{x}v$ = (-b cos hv sin u, b cos hv cos u, o)



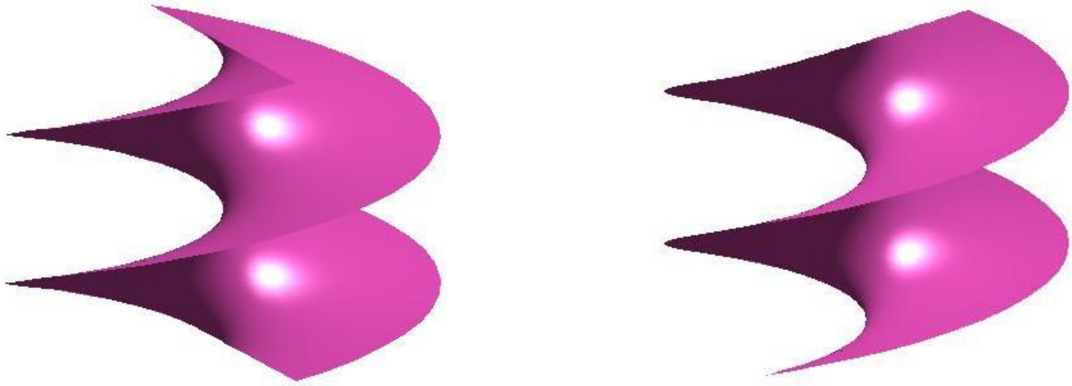


Figure 3.2: The α-helix. Image courtesy of cmgm.stanford.edu

Figure 3.3: The helicoid

Conclusion

This Clear from basic results of Calculus of variation nanely the Simplest Euler-Lagrange equation and have examined the Connection to minimal surface In Considering minimal Surface, we said that the lone between the helicoid and elocs. One of the most Common repeating units of protein Structure and then extended this Connection to derive two Euler-Lagrange. Equations which are related to potential free energy functional

E(x) = $\int F$ (K) dL of Protein Structure

We can use these two Euler-Lagrange eqution to derive different discussion of Some possible solution. The article Me Coy [Me co$_8$] Natunchy we could to want restrict our self F(k) that admit helics as minimizing solution to the energy functional E(x) there solution Could shed Some light on protein Structure different angle, which are current a Ve nues of research

[BF 09,FNS05, It MT08 McC08]

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