MAPLETS FOR MULTIVARIABLE CALCULUS

José D. Flores, PhD
Department of Mathematical Sciences
The University of South Dakota
414 East Clark Street
Vermillion, SD 47069-2390
jflores@usd.edu

Introduction

In recent years a significant number of interactive tools have been created to display mathematics over the internet using any web browser. Two of most well known software are *webMathematica* (see [3, 6]) and *MapleNet* (see [3]). Educators engaging in the use of the internet in teaching Mathematics are using interactive tools to present and discover mathematical concepts. The use of animations and interactive teaching material in multivariable calculus and other upper division mathematical courses such as differential equations are widely available on the web, see for example Blanchard [1], Knisley [4] and Stroyan [6]. Animating multivariable concepts enhance the ability of the student to comprehend the dynamics of three dimensional mathematical concepts. With this philosophy in mind we have created a package with Maplets that contains animations for the concepts covered in a multivariable calculus course.

Background

The Maplets package of Maple allows designing graphic interfaces with the capability to interact with the mathematical kernel. With this tool we have developed a package of Maples for the Multivariable Calculus course, Flores [3]. The Maplets are generated basically using *Maple* code and then displayed over the web as JSP applications through MapleNet. The use of Maple through MapleNet gives the user with access to the internet using any browser the interactive capabilities of the animations.
The advantage using interactive tools such as the Maplets is that it takes away the somehow complicated code to investigate the concept. The Maplet as well as other similar web applications allow the user to enter a minimum codify information. The required information is usually a function of one or two variable with its corresponding domain, in addition to other minimal information. The main goal of the application is for the user to experiment and discover mathematical concepts, develop the intuition and make conjectures.

Motivation

To motivate this presentation we refer to two examples that we cover in the syllabus of the multivariable calculus course.

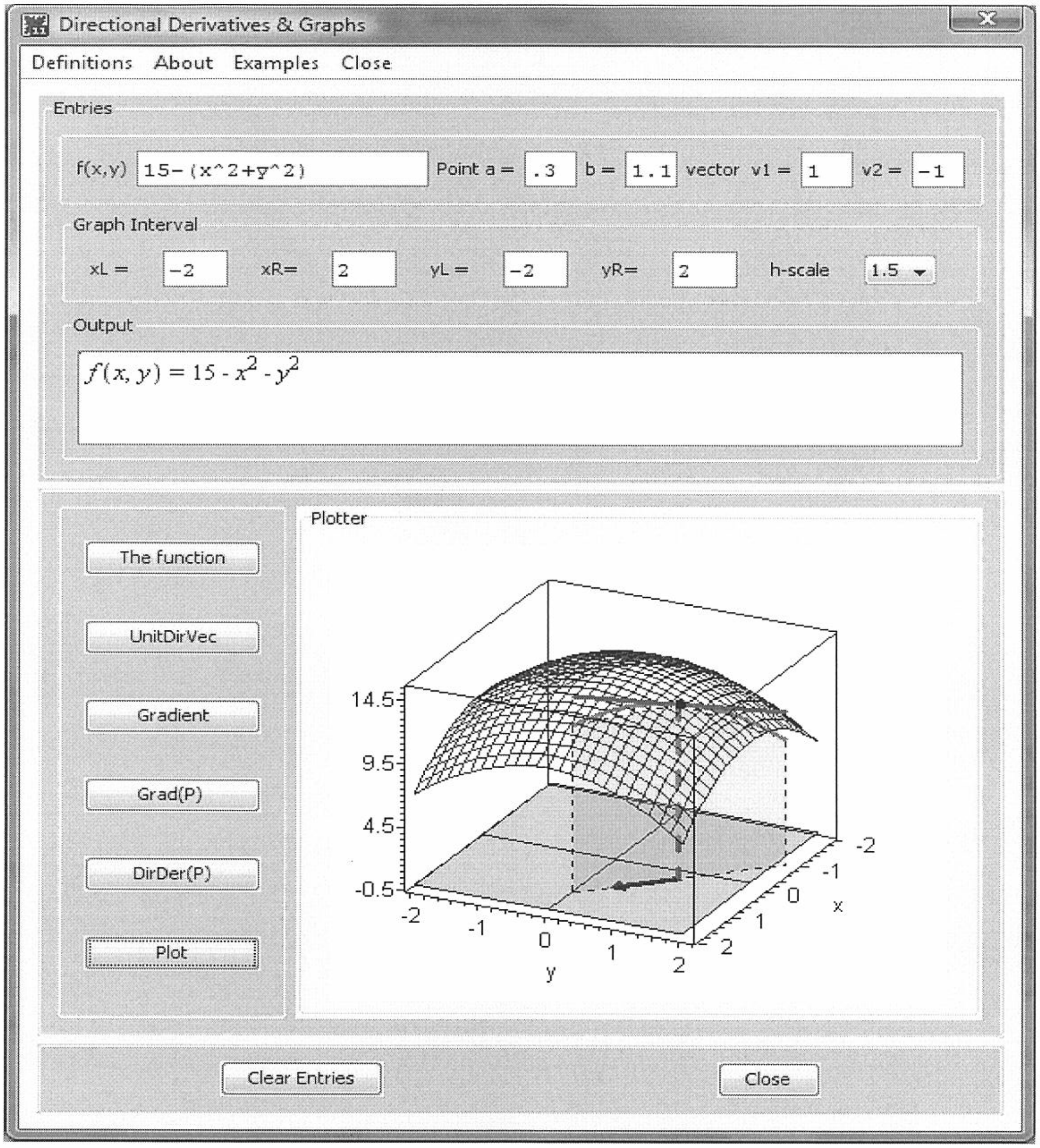

Figure 1: Directional Derivative

Example 1: Students can experiment when covering the concept of directional derivatives, Figure 1. The user can interactively compute the directional derivative and has a visualization of his/her finding. The input is the function of two variables f(x, y), the point (a, b) where the directional derivative will be computed and the direction vector given the direction of the required derivative. It also required inputting the domain for the graph to be plot. The user can input several direction vectors and discover interactively how the rate of changes will vary in each direction. Moreover, the user will be able to visualize the direction of the maximum/minimum rate of change instead of merely calculating them by hand.

Example 2: The Lagrange method in Figure 2. In general students learn the manipulations to calculate the extrema of a given optimization problem, but in general they do not really understand the concept behind what they are computing. The basic idea of this Maplets is to visualize the result of the Lagrange Theorem, that is, locate the extrema of a function f(x,y) subject to a constraint g(x,y)=0 satisfy the condition

$$\nabla f(x,y) = \lambda \nabla g(x,y)$$

The Maplets shows the constraint curve at the base of the system, it also shows the image of the constraint curve mapped onto the surface. Using the left slider the horizontal plane moves up and down and as the plane intercepts the surface it creates the contour curve. That is, the animated elements here are the plane and the contour curve. It is precisely at this point where you can explain to the students the Lagrange's equation. When the contour curve becomes tangent to the constraint curve "the gradient vectors are parallel", and this occurs only when the horizontal plane has reached the extrema. The interactive animation of the Lagrange's problem gives the students an intuitive idea of the problem that they will need to compute.

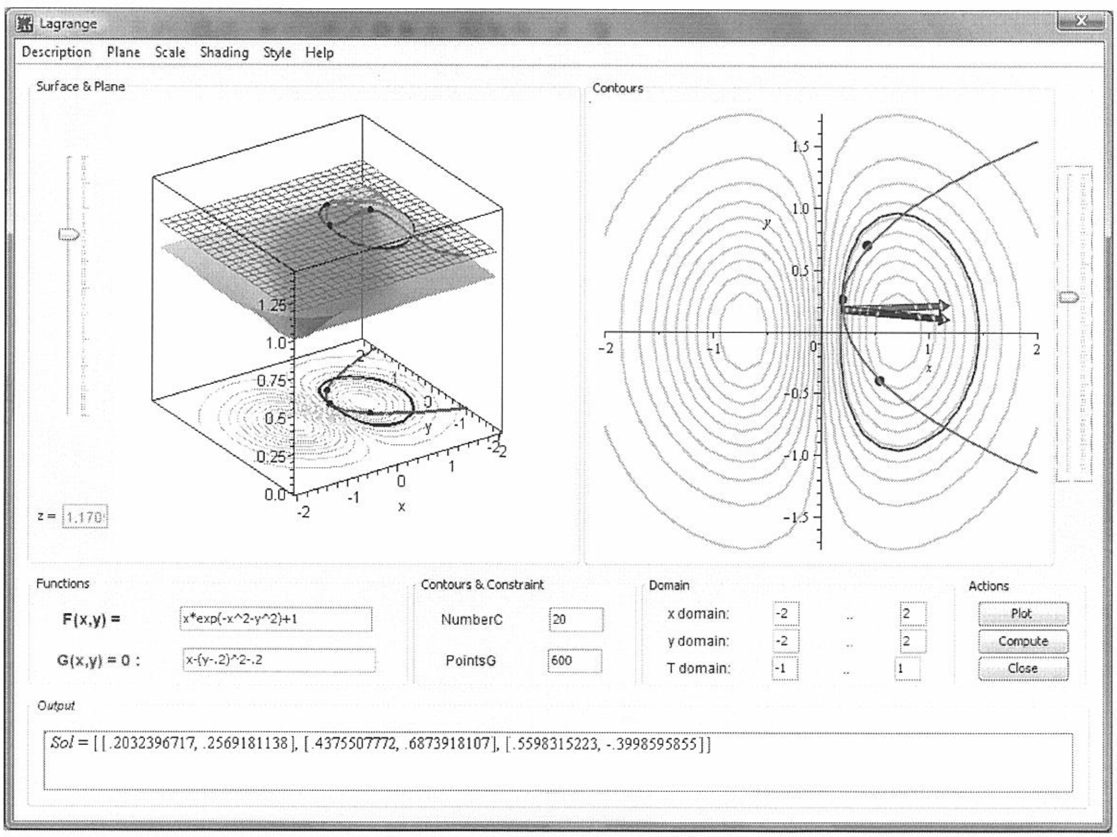

Figure 2: Lagrange multipliers

Summary

The incorporation of the Maplets as part of the lectures brings to the classroom the dynamics of three dimensional mathematical objects to create a more active way of teaching multivariable calculus. The interfaces provide the instructor and students with simulations bringing mathematical concepts alive. The interactive Maplets permit students to manipulate the graphics to enhance their understanding of mathematical concepts.

References

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