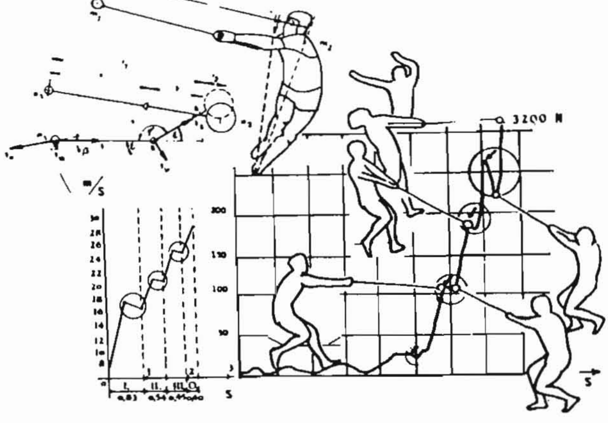
A MOTION FEEDBACK SYSTEM

Ladislav Pataki, Ph.D.
Sybervision Systems, Inc.
Training Management System

The purpose of this paper is to introduce an interesting approach to building multi-purpose measuring equipment for use in a wide variety of athletic motion. The emphasis here will be not so much to delve into the actual research results, but rather to introduce the project, the ideas behind it, and the team that worked on the project.

Technique



Introduction

As we know, motion has both kinematic and kinetic structure. The kinematic structure may be observed and therefore is for most coaches the primary basis for the analysis of the sports motion technique. The source of any movement involves the exercise and distribution of forces. Therefore, it becomes extremely important to understand these forces especially when one is dealing with the motion of elite athletes.

In biomechanics, force platforms, strain gages, and accelerometers have been used for this purpose. The following work focuses on the development of measuring equipment that provides instant feedback of the athletic motion and that also provides feedback to the athlete immediately after his/her performance, to help guide his/her progress in the next attempt.

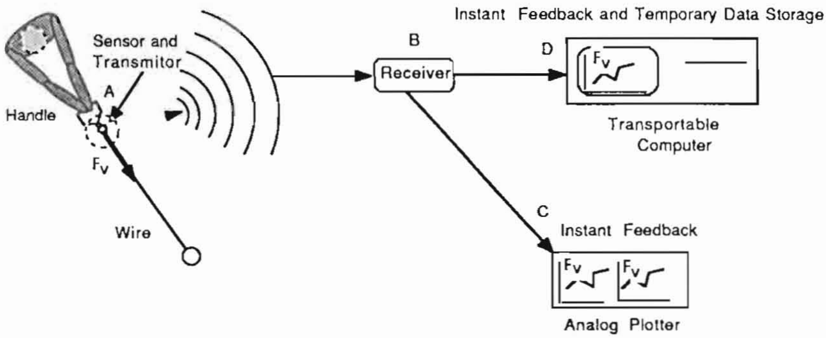
The unique product of this project is a videotape which simultaneously shows both the athlete's actual motion and the biomechanical parameters measured by our equipment as they occur at each given instant. The system trademark is the Motion Feedback System. (MFS)

This system is the result of a research effort of the Training Management System team and its production will further enhance SyberVision System's position in the forefront of video athletic achievement instruction.

The prototype being developed for Olympic sports is a strain telemetering system used for hammer throwing. Hammer throwing was selected for the initial development project because of the close relationship between Ed Burke and myself. Ed Burke is a four-time Olympian and chairman of hammer throwing for the U.S. Track and Field Congress. He provided access to a group of athletes eager and willing to test the device. The equipment is the result of work done by an enthusiastic team consisting of William E. Firth (project manager), David P. Schwartz from Accurex Corporation, Edward L. Rossiter (also from Accurex Corporation), and my friend John Lochner, former mayor of Los Gatos, California. Without their efforts, skills, and hard work, the project would not have been successful.

In hammer throwing, strain gages were used to measure the strain exercised on the wire as early as 1967 by Soviet sports scientist, Baltovskij. They were also used by Achel, Gy. and Kapcsos, L. (1977) and Pataki and Ramacsay (1981). All the equipment used in the above research was non-telemetric equipment. The wiring necessitated the placement of the strain gage between the hammer and the measuring equipment, thus encumbering the athlete. The MFS equipment is telemetric equipment which allows the athlete complete freedom of motion. Technically, it would be possible to use this equipment during actual competitions. (Figure 1)

System Diagram of the Force Telemetering System



A - Measurement and transmitting a wire force (Fv)

B - Receiving the signal

C - Displaying the time series of the force (Fv) for the athlete and coach

D - Computation, displaying and temporary storage of data

Figure 1

Results confirmed that the curve of the linear velocity during the throw was similar to the curve of the strain in the wire. This indicates that measuring the strain on the wire can provide useful feedback for the athlete.

In Pataki and Ramacsay (1981), a very significant correlation (R = 0.951) was shown between the maximum force just before the implement's release and the distance of the throw (see Figure 2).

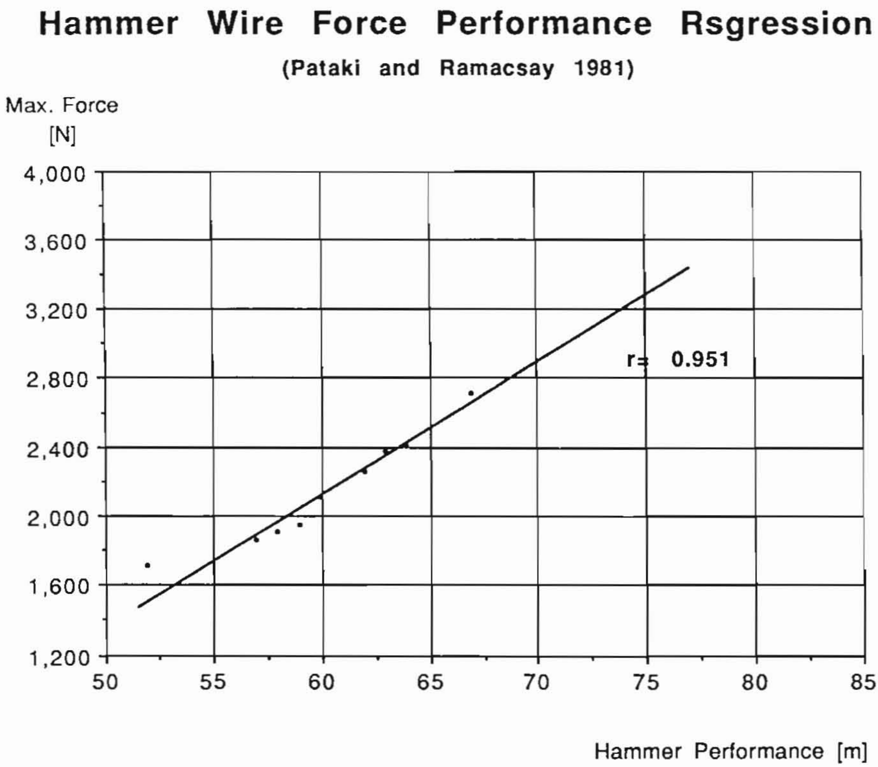


Figure 2

The strain on the wire is predictable depending on the length of the throw by the following equation: maximum strain = -2380.97 + x(70.5). The standard error of the prediction is 9.55 N. The strain in the wire, therefore, is a highly significant performance indicator.

Hypothesis

Significant differences between the profiles of intermediate and elite throwers exist and can be detected with the MFS equipment. Significant differences between the profiles of different elite throwers also exist and can be detected with the MFS equipment. Significant differences also exist in the profiles of the same athlete making shorter or longer throws and can be detected with the MFS equipment.

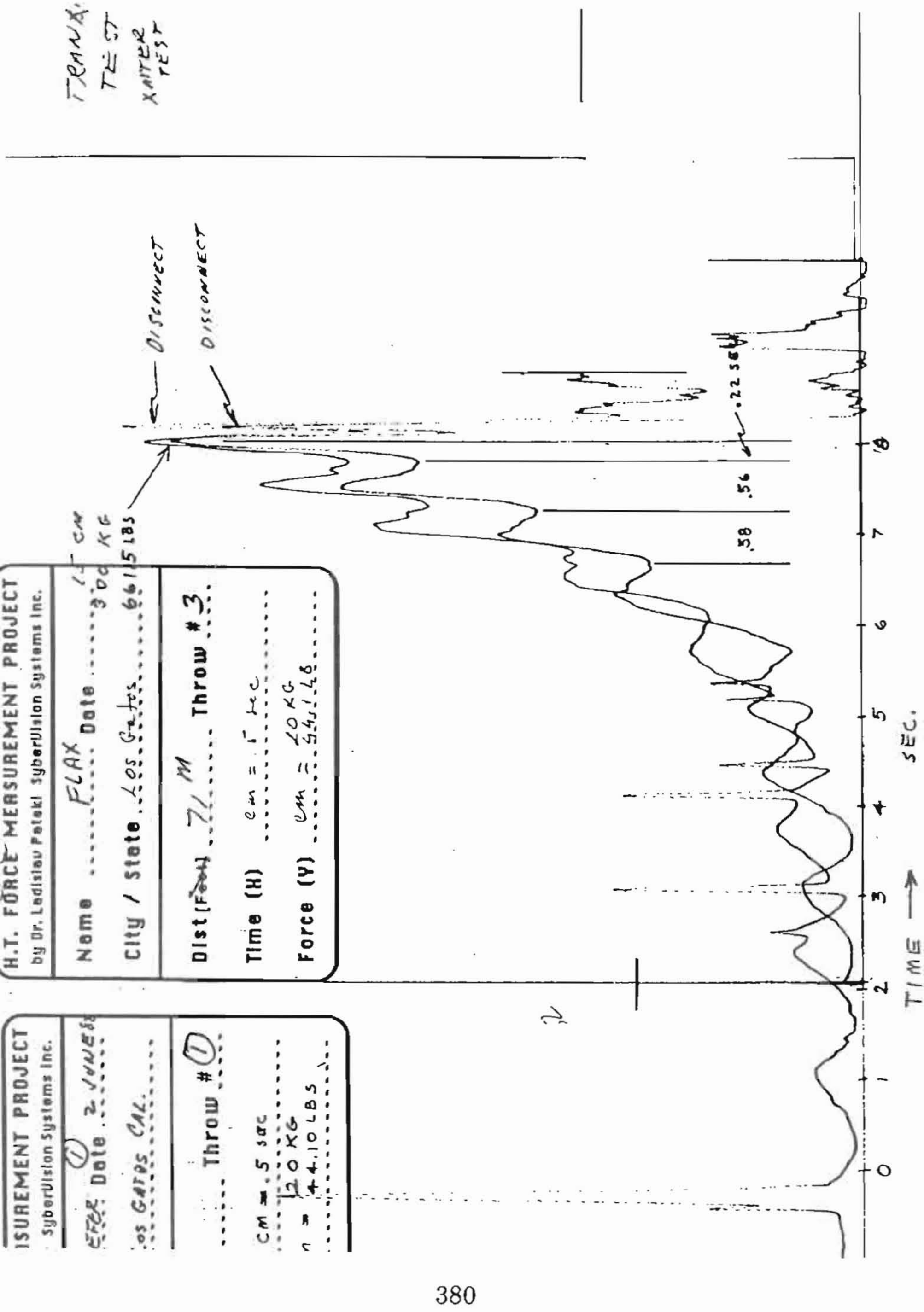
Results

Intermediate throwers generate much lower forces which correlate with lower distances achieved. Differences exist in profiles between two elite throwers, Schaefer and Flax. The MFS clearly detected the steeper increment in the force exerted on the strain wire by the athlete making three rather than four turns. The comparison of the throws of these two different athletes also indicates significant differences in the passive phase of the movement. In this phase, when the strain is decreasing, especially in the last turn, Schaefer's decrement is smoother and less pronounced than Flax's. Flax probably loses more velocity in the third and fourth turns than does Schaefer. Knowledge of this element showed one area of technical training where Flax's performance could improve.

The implement also detects differences between individual throws of the same athlete. In Figure 3, for instance, note the differences in profiles between a shorter and a longer throw of Ken Flax, an elite athlete. The higher strain during the longer throw was accumulated gradually during the third and fourth turns and during delivery. In the longer throw, the decrement in the passive phase wasn't lower. It would be desirable to lose less velocity, as has previously been indicated.

During two throws of a West German, world-class athlete, Schaefer, the athlete achieved approximately the same level of strain before delivery of the hammer, but he achieved it with two different patterns. In the first throw, the force after the last turn was significantly lower than in the second throw, but in the passive phase of the first throw the decrement was significantly smaller, which helped him achieve the same final result. A comparison of the second and third throws by Schaefer indicates very similar patterns of forces. The first throw was an anomaly, while the second and third were almost alike.

Figure 3



H.T. FORCE MEASUREMENT PROJECT
by Dr. Ladislav Pataki SyberVision Systems Inc.
Name FLAX Date
City / State Los Gatos
Dist Throw # 3
Time (H)
Force (Y)
ISUREMENT PROJECT
SyberVision Systems Inc.
Date
Throw # 1
DISCONNECT
DISCONNECT
661.5 LBS
.58
.56
.22 SEC
TIME →
SEC.

Conclusion

Field trials have demonstrated that the equipment prototype does, indeed, have the necessary sensitivity to detect and identify precisely significant differences in strain patterns. It can provide useful feedback for athletic training. Continuation of the development of this system is worthwhile.

References

Achel, Gy. and Kapcsos, L. (1974) *A. Kalapacsvetes es Gerelyhajitas ero es Sebesseg Valtozassanak Meres*, Budapest Muszaki Egyetem(nonpublished).

Baltovskij, A. I.(1973) *Komplexnaja Ocenka Techniki Metanija Molota*, Voprosy Teooorii a Praktika Fiziceskoj Kultury I Sporta, Minsk .

Pataki, L. and Ramacsay (1982). L., *Kladivar a Odstrediva Sila* (The Hammer Thrower and Centrifugal Force), Atletike, 6,22.

Pataki, L. et al.,(1977) *Zrycholovanie Kladiva v Obratkach*, (Acceleration of Hammer in Turns), Teor. Praxe tel. Vych, 25 , 8.

Tutevic, V. N. (1969) *Teorija Sportivnych Metanij*, FIS, Moscow, pp 248-293.