

Consensus Document of the Workgroup BioNet_VRLab

Draft – version R5

Wednesday, 29 May 2002

Extensor: Marco Viceconti

Revisers: BioNet_VRLab mailing list

Introduction

This document is the result of a consensus process, promoted by the BioNet consortium within the biomechanics community, which has consisted of three separate phases.

Through the BIOMCH-L mailing list, more than 4000 researchers were invited to suggest controversial topics in biomechanics. This produced seven general topics, which were extensively discussed – again on BIOMCH-L – one by one, by the whole community. As the discussion focused, the organisers also invited colleagues known to have significant experience in the specific context, to provide contributions to the discussion and to help in structuring the resulting positions. The process continued until the end of the first day of the BioNet Event, during which many invited speakers contributed to the discussion with their presentations. The final result was a list of 15 statements addressing a variety of issues – details can be found at http://www.mk.dmu.ac.uk/bionet/event_getitoff.htm.

On the second day of the Event, each statement was briefly presented by a speaker, usually the colleague that most actively promoted that particular proposition during the preliminary discussion. To make the discussion of the statements more effective, three workgroups were created. The smaller size of these groups was expected to foster active participation, especially by younger researchers, and to promote a more focused discussion. Workgroup A collected all statements relating to the inherent nature of biomechanical modelling. Workgroup B discussed all statements relating to the sharing of research results. Workgroup C dealt with the statements relating to specific research contexts, in particular ergonomics, safety and biomaterials-tissue engineering. For each workgroup, a rapporteur provided a brief summary of the consensual conclusions to the subsequent plenary session. The final addresses of John O'Connor (University of Oxford) and Steven Stanhope (National Institute of Health, USA) provided, respectively, a European and an American perspective on the work done.

For each main topic (modelling in the support of physical mobility, sharing research data, biomechanics in ergonomics and safety, biomechanics in biomaterials and tissue-cell engineering) the BioNet consortium created a web-based discussion forum (called BioNet_Mobility, BioNet_VRLab, BioNet_Safety and BioNet_Materials) which was used to continue the discussion and to collectively revise the final consensus documents of the event.

The present document constitutes the consensus paper of the workgroup BioNet_VRLab.

Statements Discussed in Workgroup B

Statement #6: Tom Kepple

Research-funding agencies should require that all data produced with their money are made publicly available

Statement #7: Georg Duda

We should create a single distributed repository of all the biomechanical information that are used in musculo-skeletal information.

Statement #8: Panos Diamantopoulos

We should develop guidelines on conducting biomechanical research

Statement # 9: Marco Viceconti

A global data repository should be organised around a virtual community model

Executive Summary

Following long discussion, which is described in greater detail later in this document, the BioNet_VRLab Workgroup agreed that:

- sharing research results is, in general, a valuable process that can make our research results more relevant for humanity
- in most cases, the sharing of research results is expected to provide a positive effect on biomedical research
- public research-funding agencies and charities should require that results produced with their money are made publicly available, unless specific reasons make it impossible or inappropriate, but only if they can provide funding for the sharing activities
- the approaches adopted so far to share biomechanics research results have not been effective in promoting a direct or indirect commercial exploitation of the research results, nor even for collecting sufficient revenues to maintain the sharing effort
- a more structured approach to sharing is necessary, in order to exploit its value to the maximum, as well as to promote the sharing culture inside our community
- the creation of a global community would make the sharing of biomechanics research results much more useful and effective
- sharing initiatives should be organised under the common umbrella of a virtual community, which would be responsible for setting basic rules and procedures, monitoring processes, and fostering the creation of useful products for industrial, clinical or societal users
- a global sharing community would provide a useful structure to co-ordinate research results in answer to clinical, industrial and societal needs
- the sharing of research results would become more effective if it could rely on a distributed infrastructure supporting micro-payments, automatic accounting and billing, and policies and values that responded dynamically to changes in circumstances
- our scientific community should find a way to monitor the appropriateness of sharing initiatives, achieving an appropriate balance between control and openness
- a virtual community would provide a suitable structure for managing collective knowledge and for producing consensus statements, especially if innovative technology is available to support this process.

The BioNet_VRLab Workgroup identified various challenges in achieving the goals above:

- establishing a body of rules for the management of the community itself
- ensuring the long-term sustainability of the operation
- creating of a distributed infrastructure able to support the community, its internal marketplace, its consensus processes, and its knowledge management needs
- coping with the technical difficulties of storing and sharing complex and highly heterogeneous information
- promoting a direct or indirect commercial exploitation of research results, or simply the collection of the revenues required to maintain the sharing effort

The BioNet_VRLab Workgroup agreed that the creation of an Internet-based Biomechanics Research Community would dramatically improve the level of collaboration between research groups, with a clear synergistic effect on how we use research funding. In order to pursue these challenges, this Biomechanics Research Community needs a state-of-the-art technological infrastructure to support the information management as well as the applicability and the accountability of highly heterogeneous sharing policies.

Why Share Research Results?

Biomedical research has a long tradition of sharing. The Visible Human Project and the Human Genome Project are only the tip of the iceberg, the best known examples from a huge amount of data, models, programs and structured knowledge that has been made available to the research community as whole.

In the National Institutes of Health's (NIH) Data Sharing Workbook we read: "*Data sharing is particularly important for unique data sets that cannot be readily replicated. It promotes many goals of NIH's research endeavour, since it allows scientists to translate research results into knowledge, products, and procedures to improve human health. Potentially all data – from basic, laboratory-based research to epidemiological and clinical studies – could be shared*".

We shall henceforth focus on biomechanics, but most of observations that will be made are clearly valid also for most medical and biological engineering and physics research. This principle should apply particularly well to those researchers approaching biomedical problems from the engineering and physics perspective. Biomechanicians collect mostly quantitative data that are usually stored in electronic format, ready to be shared through digital media. They develop, and extensively use, specialised computer models and programs that require a huge effort for their creation. Biomechanics researchers, compared with other biomedical researchers, tend to produce a more structured knowledge, which should simplify its collection and accessibility.

The sharing of research results is in fact relatively common in biomechanics. Examples are the Petty musculo-skeletal database made available by NIH, the International Society of Biomechanics (ISB) data repository, the ISB finite Element Mesh Repository run by the Istituti Ortopedici Rizzoli on behalf of ISB, the HIP98 CD-ROM developed and freely distributed by a group of German universities and research centres. More recently, the European Commission partially supported institutions in Italy, UK, Belgium, Greece and France in creating the VAKHUM data collection.

There are also many examples of sharing in the area of specialised computer model and software: Move3D developed at the NIH, the Hip-Op surgical planning software developed at the BioComputing Competence Centre in Italy, the Danish AnyBody project, to name but a few.

The group discussed the opportunity to share research results. It was mentioned that publication is already a form of data sharing. However, there are various situations in which access to the raw data may create additional research opportunities. In addition, the mere production of a block of useful results is sometimes perceived as insufficient to justify a publication. Thus, in principle, there is a need in the community to create other mechanisms to share research results.

Some scientific journals have recently started to enrich published scientific papers by making additional related material available on the journal's web site. However, some colleagues pointed out that, since the additional material is not peer reviewed, this practice is no different from a direct sharing of results, except for the fact that the publisher collects most of the sharing effort undertaken by somebody else.

Workgroup BioNet_VRLab agreed that sharing research results is, in general, a valuable process, and that it may have a very positive impact on the development of biomechanics. It was also agreed, in principle, that sharing could help the dissemination of biomechanics knowledge within clinical practice, industry and the social services. Thus, in principle, sharing research results could make our research results more relevant for humanity.

The discussion during the BioNet Event made apparent that, while most research groups in biomechanics are ready to share data, the motivations for sharing are diverse. One motivation, which is probably behind the current examples of free sharing based on voluntary effort, is "because it is the right thing to do". Thus, in some cases this is perceived as an ethical obligation of our profession. In a similar way, some colleagues supported the perspective that research carried out at public institutions and fully supported with public founding should be made research results free available. With this respect, Workgroup BioNet_VRLab agreed that, in principle, **public research-funding agencies and charities should require that results produced with their money are made publicly available, unless specific reasons make it impossible or inappropriate, but only if they can provide funding for the sharing activities.**

A second group of motivations are internal to the scientific process. It was pointed out that it reinforces open scientific enquiry, encourages diversity of analysis and opinion, promotes new research, allows the testing of new hypotheses and alternative methods of analysis, simplify replication of experiments, etc. Some colleagues observed that in some cases the results are so related to the study which generated them that they are useless outside the context in which they were generated, and in some particular cases, they may even produce confusion and erroneous opinions. However, workgroup BioNet_VRLab agreed that **in most cases the sharing of research results is expected to provide a positive effect on biomedical research.**

The third and last group of motivations related to the possibility of creating business opportunities. Most colleagues agreed that this is not necessarily in contrast with the other motivations, as the creation of entrepreneurial activities may generate employment opportunities, create and distribute wealth, and may contribute to a sustainable and harmonious economical growth of society. In some cases, income from the sharing process could eventually support the process itself, ensuring a long-term sustainability of the sharing effort. In other cases, research results, eventually combined and integrated, could be directly sold to industrial or clinical customers, thus providing a way to collect private funding for the research activities. Last, but not least, the sharing of research results could foster the creation of spin-off companies or of new market opportunities for existing companies. There was consensus that the **approaches adopted so far to share biomechanics research results have not been effective in promoting a direct or indirect commercial exploitation of the research results, nor even for collecting sufficient revenues to maintain the sharing effort.**

What is Wrong with the Methods Currently Used to Share Research Results?

During the BioNet Event, various limitations of the sharing approaches currently used were made evident. To focus on these problems, it is useful to relate them to the aforementioned motivations for sharing. So far, the institutions funding biomechanics research have not enforced, or even promoted, the sharing of results, although the NIH is currently preparing a policy in this sense. Thus, the decision to share results is left to the single institution, or even to the single researcher. In fact, the most valuable sharing efforts in biomechanics exist only because of the personal commitment of some colleagues.

This creates a variety of problems. Over time, researchers change interests, relocate, and even leave their research job. When this happens, the shared results are no longer maintained and quickly lose value or even become unavailable. Also, the cultural approach towards voluntary sharing efforts is uneven within the community. Some groups promote such a culture among students and researchers, while others mostly ignore it or even oppose it. The BioNet_VRLab Workgroup agrees **that a more structured approach to sharing is necessary, in order to exploit its value to the maximum, as well as to promote the sharing culture inside our community.**

The current fragmentation of sharing initiatives tends to prevent any synergistic effect. It is also evident that the nature of the current sharing experiences tends to promote the creation of micro-communities – one for each sharing effort – but not the creation of a global community. The lack of co-ordination is evident in the substantial inability that biomechanics research shows in establishing internal and external consensus positions. Some colleagues raised the need for internal consensus processes, especially in relation to methodological issues, in order to foster an improvement in the quality of biomechanics research, and the support the younger researchers and smaller labs. A related issue is the relatively low level of awareness that each sharing initiative raises within the research community. Although the existence of widely read media such as BIOMCH-L makes it possible to post announcements, newcomers frequently ignore the existence of such on-line resources, and “re-invent the wheel”. We agree that **the creation of a global community would make the sharing of research biomechanics results much more useful and effective than it is currently.**

Many colleagues noticed that biomechanics research has problems in having its achievements recognised and widely used in the clinical, industrial and societal contexts, although such results are clearly of great value in these areas. **A global sharing community would provide a useful structure to co-ordinate research results in answer to clinical, industrial and societal needs.**

At present, the sharing of results does not always produce a positive effect on biomedical research. Spontaneous sharing does not, in general, widely support the necessary quality control of the results that are shared. Because of the fragmentary nature of these sharing efforts, it is currently quite rare to see such

efforts being merged and structured into “products” for external users, either industrial, clinical or the citizen at large. We agreed that **sharing initiatives should be organised under the common umbrella of a virtual community, which would be responsible for setting basic rules and procedures, monitoring processes, and fostering the creation of useful products for industrial, clinical or societal users.**

As mentioned above, previous approaches to sharing biomechanics research results have not been effective in promoting a direct or indirect commercial exploitation of research results, or simply the collection of the revenues required to maintain the sharing effort. Although many research activities produce something of value, only rarely are such outcomes exploited commercially. In most cases, the data, models, algorithms could eventually be sold to other researchers, but only if a solid structure for supporting this very particular type of e-commerce is available. Otherwise, the small value of each result does not justify the effort of set-up such an infrastructure.

Another problem is the lack of dynamic management of the value. Those who can set-up a rudimentary e-commerce setting around their sharing effort, have difficulties in adjusting the sharing policy dynamically with the evolution of the state of the art in the community. During the discussion, many colleagues suggested that such virtual market might not necessarily rely on financial value, but rather promote the exchange of goods and services within the community. If managed properly, such a sharing mechanism would also help to level the playing field, helping to compensate for differences in size, infrastructure and tradition among research groups worldwide.

This point opened another discussion thread, on the opportunity of setting-up special policies to ensure that students and researchers from less developed areas can access to the all the assets of the community. All these considerations confirm that **the sharing of research results would become more effective if it could rely on a distributed infrastructure supporting micro-payments, automatic accounting and billing, and policies and values that responded dynamically to changes in circumstances.**

What Should Be Shared?

Although this aspect was not addressed by any of the statements, various colleagues raised this issue during the discussion. A first point on which we reached consensus is that not all research results can be effectively shared. Since the dissemination of scientific information in inappropriate forms may produce negative effects, it was agreed that **our scientific community should find a way to monitor the appropriateness of sharing initiatives.** The nature of such a monitoring process, its extension, the level of enforcement and the operational contexts are all arguments that should be defined through a collective structured consensus process.

Another aspect that was raised during the discussion was the need of identifying and stating the aims of a sharing effort from the beginning. It was pointed out that this should not inhibit the possibility that other researchers could make a use of the shared results that is different from that which the results’ owners originally envisioned. There was consensus on **the need to achieve an appropriate balance between control and openness.**

Most researchers agree that sharing data, algorithms, computer models and programs is, in general, very useful. However, it was also pointed out during the discussion that information, when managed into usable form, could be another important resource to share. Two specific examples were made:

- the ability to reach consensus on the methodological state of the art of given research practices would help the rapid growth to excellence for young researchers as well as for small and/or disadvantaged research units;
- the possibility to reach a wide consensus on specific biomechanics issues that could be presented as recommendations to the healthcare system and to the public at large.

It was agreed that **a virtual community would provide a suitable structure for managing collective knowledge and for producing consensus statements, especially if innovative technology is available to support this process.**

What are the Challenges?

Various challenges were identified during the discussion. The most important is probably, as in any community, the need for **establishing a body of rules for the management of the community itself**. Again, for each specific aspect (quality control, sharing policies, the respect of general rules such as patient's privacy, etc.) the challenge will be to strike the proper balance between control and openness. Not surprisingly, the biomechanics virtual community could become a perfect research laboratory for those interested in political and social sciences.

There was consensus that, at the beginning, it will be necessary to set very few fundamental rules – a constitution – on how to manage the consensus process, and on how to join and leave the community. Subsequently, access rules will be applied to create the community, while the consensus process will be used to set all the other internal rules. An aspect that must be agreed at an early stage is how such a community relates to other existing biomechanics organisations, such as the scientific societies.

A related challenge will be the creation of the conditions to ensure that the community is run not only during the development phase, expected to last five to seven years, but also **to ensure the long-term sustainability of the operation**. This can happen either through permanent financial support from public institutions and/or the creation of self-supporting mechanisms that will allow some entities to run the community with a profit. Collaboration with the consortium by commercial operations, as well as of large-scale computer infrastructures, should provide all the necessary expertise to deal with this aspect.

Another challenge is the **creation of a distributed infrastructure able to support the community, its internal marketplace, its consensus processes, and its knowledge management needs**. It was agreed that it would be very useful to involve in the project many computer scientists doing research on these topics, in order to ensure that we use state of the art technology to address each of these needs.

A more technical issue is **coping with the technical difficulties of storing and sharing complex and highly heterogeneous information**, with reference to experimental conventions, file formats, computer interoperability, etc. Related technical issues come from the need for methods allowing the preliminary exploration of the shared information before downloading.

To ensure a suitable design, the community should be organised after a precise paradigm. Two were suggested: the *virtual laboratory*, and the *virtual marketplace*; a possible amalgamation of these concepts is that of existing companies. There was consensus that **previous approaches to sharing biomechanics research results have not been effective in promoting direct or indirect commercial exploitation of the research results, nor even in collecting sufficient revenue to maintain the sharing effort**.

A similar point made during the discussion was how useful it could be for one research group to buy research services from another research group owning specialised instruments or specialised knowledge. This is particularly true for biomechanics, due to its trans-disciplinary nature. In principle, everybody agreed that there are many situations in which this could be very useful. However, this is currently quite an unusual way to collaborate. The problem is that, when the small size of the activities or the lack of bi-directionality do not allow the justification of a formal joint research, no other approaches are currently available. We need a kind of marketplace in which each group can dynamically advertise not only its capability but, even more important, its availability. We also need a form of barter and/or of micro-payment, that makes it reasonable, and attractive, to perform small services. In other words, **the creation of an Internet-based Biomechanics Research Community would dramatically improve the level of collaboration between research groups, with a clear synergistic effect on how we use research funding**.

The final issue raised concerned management of the different sharing policies. Public institutions such as the NIH will continue to share freely their research results, although some of them may require that the access to such knowledge is restricted to only a part of the worldwide research community. Other institutions are willing to exploit their research results commercially, but each institution will want to establish the details of the sharing policy, i.e. providing free access to certain sub-groups because of ethical, political or cultural motivations. In many cases, the same institution may require different policies to be applied to different research results, or to modify such policies over time. This has to be done in a way that does not pose any technical or administrative burden on the researchers. Thus, **the Biomechanics Research Community needs a state-of-the-art technological infrastructure to support the information management as well as the applicability and the accountability of highly heterogeneous sharing policies**.