A PROPOSAL TO INTEGRATE ANIMATION AND VISUALIZATION TECHNIQUES

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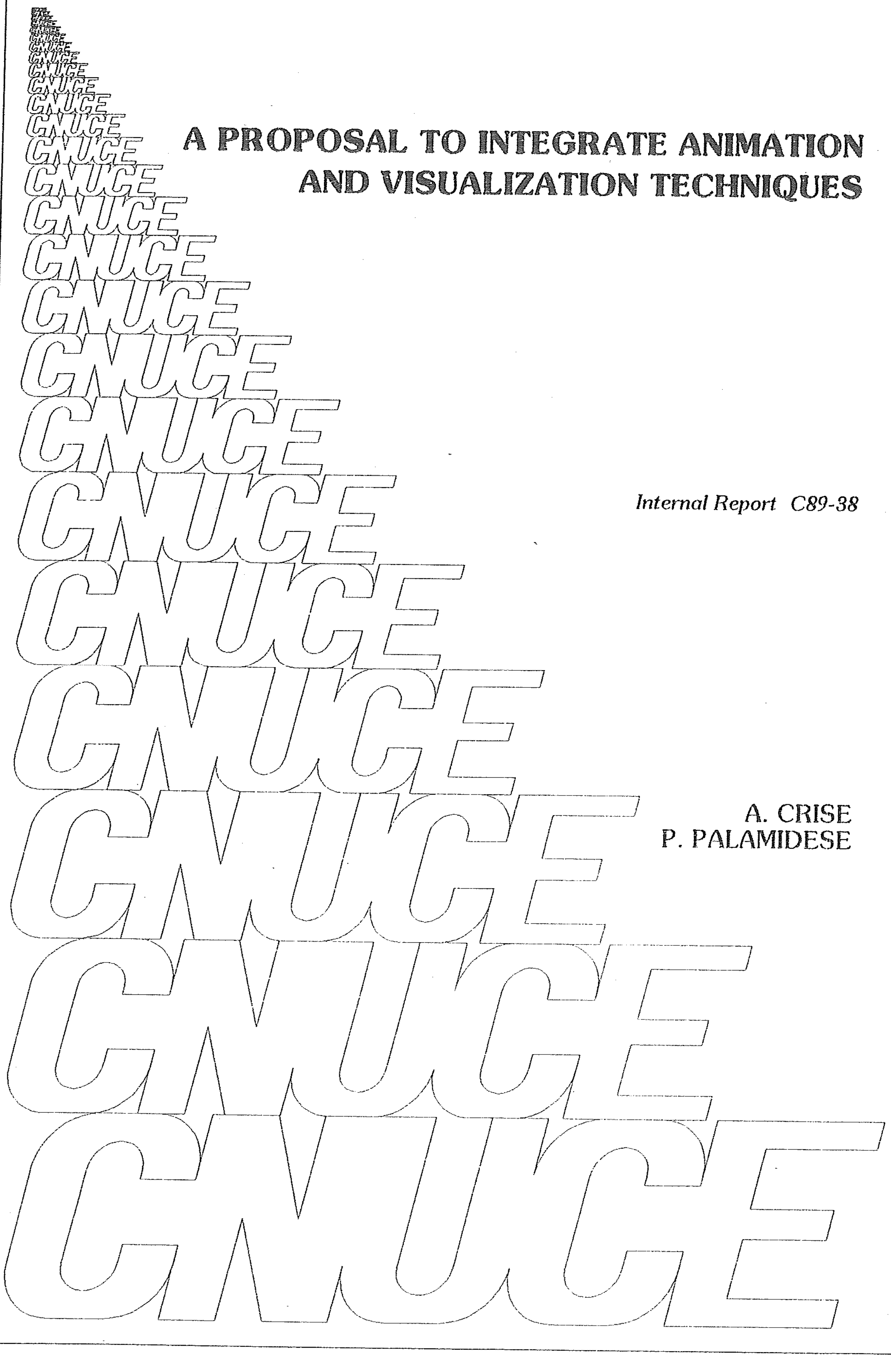

A proposal to integrate animation and visualization techniques*

When we'll be able to simulate "the real world in real time", there will be many areas which will use this technology [1]. Most of the work that has been done up to now is just an approximation to that. There are still limitations in real time performances and in world domain. The closer we get to these goals, the larger the users community will become.

Historical considerations

Let us consider the major developments of animation techniques from an historical point of view. This improvement has enlarged the animation domain, that is the set of "objects" which can be animated.

Traditional animation was "a technique in which the illusion of movement was created by photographing a series of individual drawings" [2]. Computer became later a useful tool to help animators to build frames, mainly mechanizing repetitive and manual tasks (Computer Assisted Animation).
Typical applications were cartoons, commercials; visual effects in movies, education, pubblicity.

A second step was the creation of three-dimensional graphical objects via computer and, as a consequence, the possibility to represent the world (Modeled Animation). Modeling tecniques have been developed to represent geometry and properties of materials in presence of light sources. Surfaces, solid objects, gas can now be reproduced. Many applications have been developed with these techniques not just for entertainment. The possibility of building 3D object has been widely used in simulation (robotics, flight simulations, space research, solid and articulated objects,..). Complex models for animation don't contain just geometric information or material characteristics, but also properties related to motion. This allows calculation of objects behaviour in the world.

Animation domain

The most complex domains of animation are the "physical world" and the "scientific world". These two realities must be modeled in order to represent their behaviour properly.

In the first case we deal with physical objects that is objects characterized by a shape and dynamics properties. A big work has been done to create mathematical representations to achieve one or both of the following objectives:

- realism of motion
- realism of light

Results have been obtained in modeling rigid objects (car) , flexibles objects (chain) or even set of living creatures (birds) and there are examples of their behaviour under

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* This article has been presented as a postion paper at the Workshop on Motion Control organized by the EUROGRAPHICS Working Group on "Animation and Simulation", Batelle Memorial Institute, Geneva, June 20, 1989.

different circumstances (forces, specific environment) [1]. The theoretical foundation for modeling real motion resides in mathematical science and engineering, while the fundamental of realism of light belongs to physical light theory .

The "scientific world" is made of natural phenomena, some of which are not even visible events. Nevertheless their visualization can help understanding how some features evolve in space and in time. Hence, animation of a physical phenomena has the following objective:

- scientific insight

Phenomena modeling is performed through computed simulation based on mathematical theories which are specific of any discipline (molecular dynamics, quantum chemistry, fluid dynamics,..). Since these phenomena are usually defined not by a geometric shape, but through a set of parameters, visualization requires a further step to derive one or more "physical models" suited for representation. Sometimes a geometric shape is associated to the phenomena (wind on a wing of a plane), but even in this case we can decide not to look at geometry. Geometry is an attribute like the others.

Modeling

I think the main point to clear is about modeling.
Traditionally animation deals with two kinds of models: kinematic and dynamic.

Kinematic models have been used in many applications, mainly in the entertainment area, since they are easier to use and not too much time-consuming. With this model the animator can define the trajectory of an object. In scientific field this model can be used just in very simple situations. For example: rotate a molecule or apply the oscillation law to a pendulum.

Simulation is intrinsically based on dynamic models: they include the information of physical properties. The evolution of a phenomena is computed, under special initial conditions, and the "trajectoris over time" of significant elements, are calculated. From a modeling point of view, the process evolves in the following way:

1	2	3	4	5
dynamic model ----	simulation ---	kinematic model ---	geometric model ---	animated rep.
		(trajectories)	(how is the scene)	

The kinematic model is of the type "recorded model" since it is constituted of files storing data obtained by computation. The problem with scientific events is that the original model, used for simulation, doesn't contain, necessarily, a geometric description of the phenomena. Hence, it is necessary to individuate a geometric model for representation purposes.

Our "recorded model" can be used to develop two types of animations:

A- representation of the "trajectories" described by the model
What does it mean "motion control" in this situation? Motion is traditionally determided changing one of the following elements: scene (objects and their attributes), position of observer, lights. The first condition is obtained selecting the parameters to visualize out of many possible; the other two effects can be controlled using experimented animation techniques .

B- traditional animation tecniques applied to the model at a defined time (that is on one frame):
geometric transformation

shape transformation
change of visible attributes (color, light, transparency,...)
change of light position
camera movement

- animation of light sources
  in this case are useful languages which help the animator to define type and position of light (example:ANIMEDIT [3]).

- camera animation
  zoom, spin and panning are typical camera effect together with the flying effect along a path (example Los Angeles Movie [1]).This means flying inside a phenomenon or over a region. Languages have been defined to help specifying camera movement (example MIRANIM [4]).

- special camera effects
  filters applied to a camera can help understand better (color filters, fog filters,....)? I don't have experience of that.

Motion control

It seems clear that to simulate natural phenomena we cannot use guiding systems (key frame and interpolation); program level systems (based on languages and algorithms) and task level systems (motor program handling) are indicated.

Some conclusions

Dealing with scientific problems we are at the frontier of simulation since we may have accurate representations of an event. We are also at the frontier of animation since we can calculate the forces necessary to achieve one goal [1].

The requests of simulating real world events, that is both "physical world" and "scientific world" events, accelerates the development of new powerful modeling techniques. Real problems such as robotics or astrophysical applications introduce a series of requirements: some of which are listed below:

big amount of data memorization and transmission
computer power for visualization not just for simulation
real-time animation from supercomputer
construction of complex shapes (tornado)
....

An open problem is whether animation tecniques can help increasing the scientific knowledge of phenomena.

References

[1] Visualization State of the Art
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[2] N. Magnenat-Thalmann, Daniel Thalmann
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[3] M. Fortin et all.
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Proc. Graphics Interface '85, pp.45-55

[4] N. Magnenat et all.
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Human body animation: a survay
The Visual Computer 3 (1988), pp.254-264

Part II

The scientific point of view

The aim of science is to understand deeper and deeper natural phenomena. In this case 'to understand' means to describe the phenomenon under study according with formal rules, i.e. using a set of logical-mathematical laws. This set of rules defines an abstract model which is a simplification of real world, but is enough accurate to give a realistic description and a prediction of evolution, if starting conditions are set properly. As a matter of fact, when we study a phenomenon, we are able to know the model we created, not the reality stricto sensu. The more we want to improve our knowledge the more we need to refine the model, adding more realistic rules and redefining the old ones in a more general way.

The model based approach to scientific problems has its analogous also in human vision, which is the most powerful interface with external world, and for this reason is widely used as scientific communication method. Following Marr vision is tightly connected to a representation which is a "formal system for making explicit certain entities of types of information, together with a specification of how the system does this." The result of using a representation to describe a given entity is a description of the entity itself in that representation.

Human vision is always a dynamic process: if we are looking at a steady image, our perceptive system is going to focus part of the image, to move eyes, maybe to modify the head trim. So it's very intriguing that the most natural way to look at external world is to look a scene in motion: it's well known that our attention is captured easier by moving objects instead of a steady image. Animation probably will play a stimulating role because it can meet these requirements of human vision.

Maybe it's not casual that graphics representation of scientific data (i.e. the availability of images created by graphic tools to human vision) is known as ' visualization'. So our vision processes and scientific knowledge methods have some analogies that are worth to be investigated further.

Another topic to point out is the intrinsic meaning of scientific visualization. When we use images or sequences to visualize scientific knowledge we are supposed to represent our information in a quantitative way, that is our representation preserves specific relations of real world according with well defined specifications. You can think at cartographic conformal mapping or at earthquakes risk maps where it's necessary to know exactly position and/or value of the variable displayed. The quantitative approach can be better understood if we think at the difference between image processing and remote sensing of a Landsat image. Image processing techniques have always an image as input and output and give the possibility to scientist to consider the image just as qualitative support to his interpretation. The aim of remote sensing is that to transform the input image in a measured field of a physical quantity. This kind of representation can be thought as a mathematical mapping of a

subset of the real world in a subspace in which are known physical data and their mutual relationships.
But this feature, guaranteed in 2D maps, can be barely mantained in threedimensional projections; so what about animation? The actual point is another: insight and synthesis. The common use of supercomputer by the scientific community and the fast data acquisition systems produce outputs that must be managed, displayed and interpreted; if we need an insight of this huge amount of data, we must resort to the most sophisticated visualization techniques in order to have an overall view of the phenomenon. There is a popular motto that states that ' an image is more than thousand words worth'; well, if we think that an animated sequence is made of twentyfive frames per second, it's clear that this is the way to face the music'

If we recur to animation for scientific insight, automatically we loose a tight coupling with measure but on the other hand we acquire a synthetic view of the phenomenon, stressing particularly its temporal evolution. For this purpose it's necessary to rise in knowledge level identifying pattern which can be interpreted disregarding the genesis of the images from row data. By example if we look at the interpretation of a seismic section (echoes of earth collected by an array of geophones) we notice that a single record (Fig. 1) is almost meaningless, a plot of the whole array (Fig.2) gives a more exaustive view of earth interiors given by the correlation from signals close spatially. But at top level (Fig. 3- here reflecting horizons are outlined; this is an hand made operation, nowadays) the description in terms of times and spatial offset is translated in pattern of reflecting horizons (obtained by coherent signal coming from adjacent geophones). In this example (Fig. 3) we obtain a deeper knowledge of geophysical structure, simply plotting records one near each other and interpreting the result as an image and not as a multiplot.

The same type of reasoning can be extrapolated adding one more dimension at visualization: in fact animation of a scientific phenomenon means adding another dimension in the representation; though traditional animation simulates a scene evolving in time, this is not necessarily true in scientific field. We can think that, in geophysical terms, the independent variable used for animation can be a spatial coordinate or a parameter. In these cases there is no need of realism because the sequences are pure artifacts. Surely camera animation giving effect of zoom and pan can be very useful in cases in which animation is guided; a certain degree of rendering could ease the interpretation of sequence.

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(1) dynamic model ---- (2) simulation ---(3) kinematic model --- (4) geometric model --- (5) animated rep.

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Some conclusions

Dealing with scientific problems we are at the frontier of simulation since we may have accurate representations of an event. We are also at the frontier of animation since we can calculate the forces necessary to achieve one goal.

The application of animation in the scientific world is fairly uncommon except for visualization of output coming from fluid dynamic models or molecular dynamics. The reason resides in computational costs, specialized hardware and lack of knowledge of scientists, but the trend is positive and we think that in a future easier developing environment will boost strongly the use of animation for science. The more people develop "scientific world" simulations, the more the development of new powerful techniques is accelerated. Scientific problems introduce a series of requirements some of which are listed below:

big amount of data memorization and transmission
computer power for visualization not just for simulation
real-time animation from supercomputer
construction of complex shapes (tornado)

An open problem is whether animation tecniques can help increasing the scientific knowledge of phenomena and much experimentation should be done in this sense.

References

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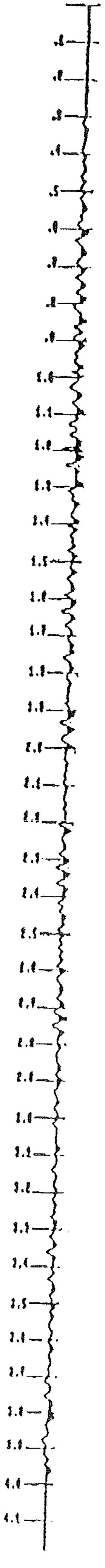
FIG 1



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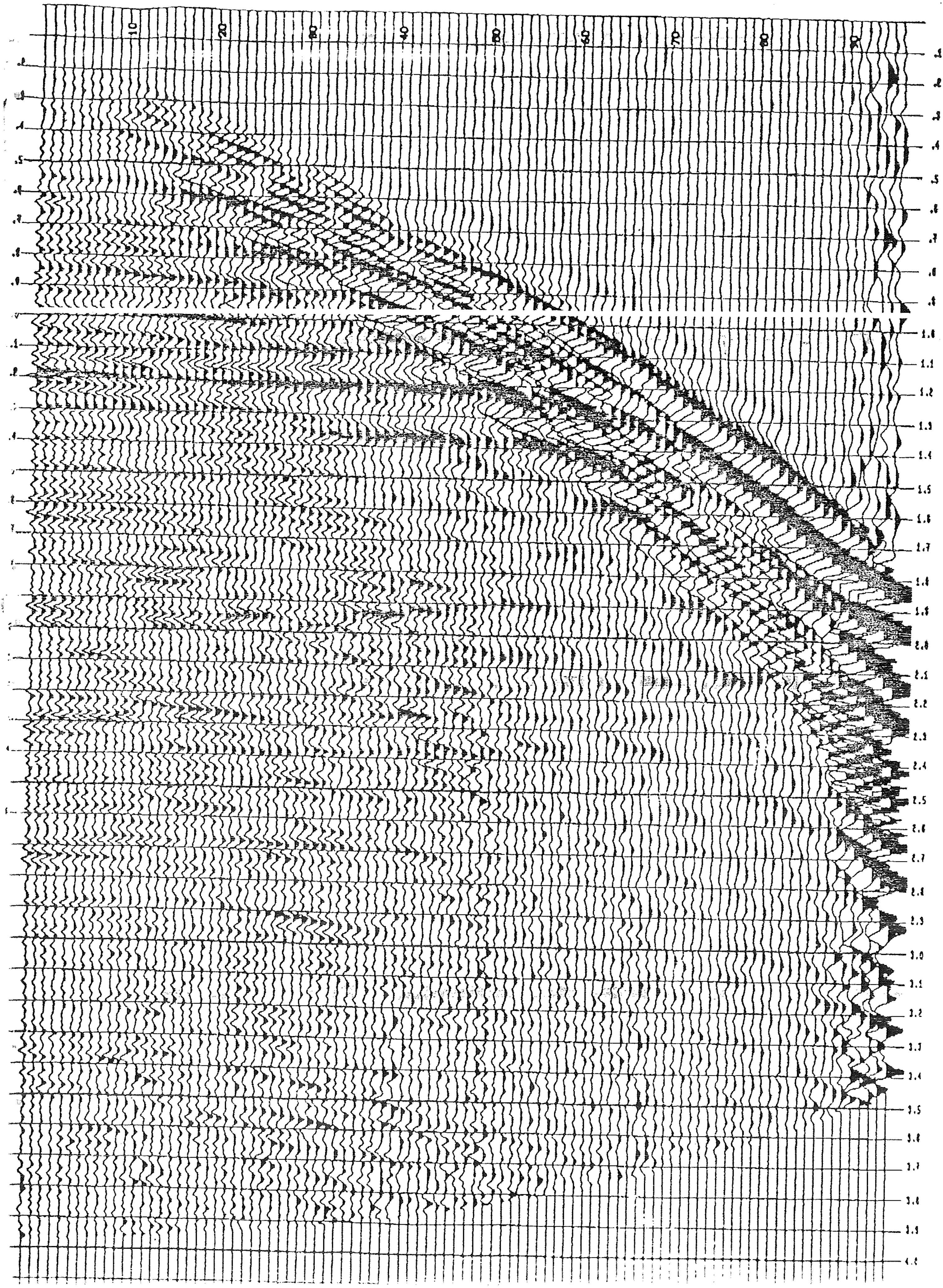
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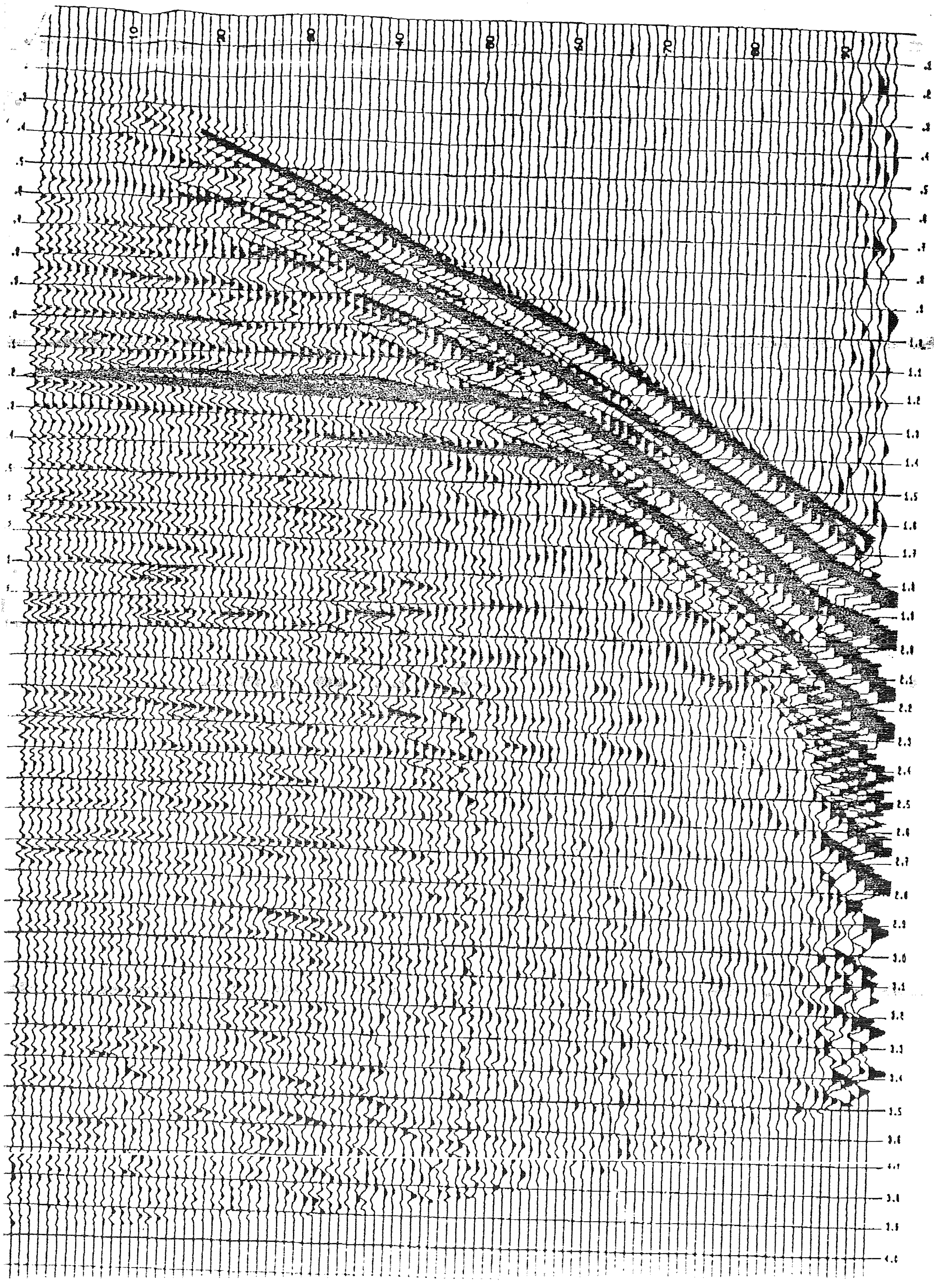
FIG 3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