The physics landsurfing boards
and
a comparison of 2-wheelers to 4-wheelers

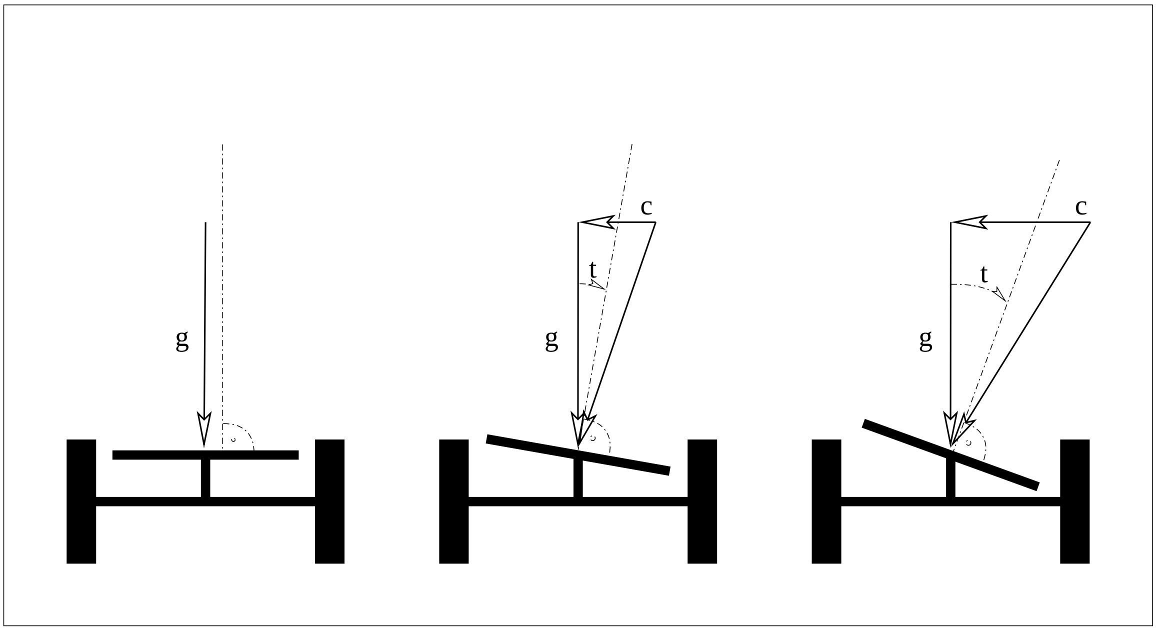

Figure 1: Deck-tilt-controlled board

1 Introduction

Since over one decade I'm building 2-wheeled landsurfing boards (windscooter and its ancestors). I'm thinking much about the physics of landsurfing and the theory behind the different steering mechanisms found in todays equipment.

Understanding the basic properties of a steering mechanism is not only a requirement for developping a new landsurfing board, but also for a rider who wants to select the equipment based on his/her riding preferences rather than the average opinion. One has to figure out, that a board alone cannot be good - board AND rider have to match. This article should help you to know about the chances and limitations of different landsurfing boards. The statements given below tell you, what the best board (of your brand of choice) can achieve. Of course, a real board available on the market needs not necessarily achieve the good properties. It can achieve it if well designed. On the other hand, you won't find a real board of any brand anywhere that achieves some property that is ruled out by the theory below.

There exist two different steering mechanisms from theoretical point of view. I call them "deck-tilt-controlled steering" and "lateral-force-controlled steering" for their characteristics I explain in the following. Both approaches have their advantages and disadvantages I'm summarizing at the end of this document.

2 Deck-tilt-controlled boards

The deck-tilt-controlled boards derive the turning radius R from the deck tilt angle t relative to the ground below (See figure 1).

All skateboards and mountainboards (3 or 4 wheels) and the very different looking flowlab board are deck-tilt-controlled. A ski or snowboard carving on the edge only without drifting, too. In general, every board, that has more than 2 wheels that are NOT on a single line is necessarily deck-tilt-controlled, no matter what the steering mechanism looks like in detail. Normal roller skates (2 wheels to the left, two wheels to the right of every foot) are therefore deck-tilt-controlled, while inline-skates even with 5 wheels are not.

The turning radius R of these boards is determined by the tilt α of the board relative to the ground, hence the turning radius is a function $R(t)$ of the tilt t. In theory it would be possible to make R a function

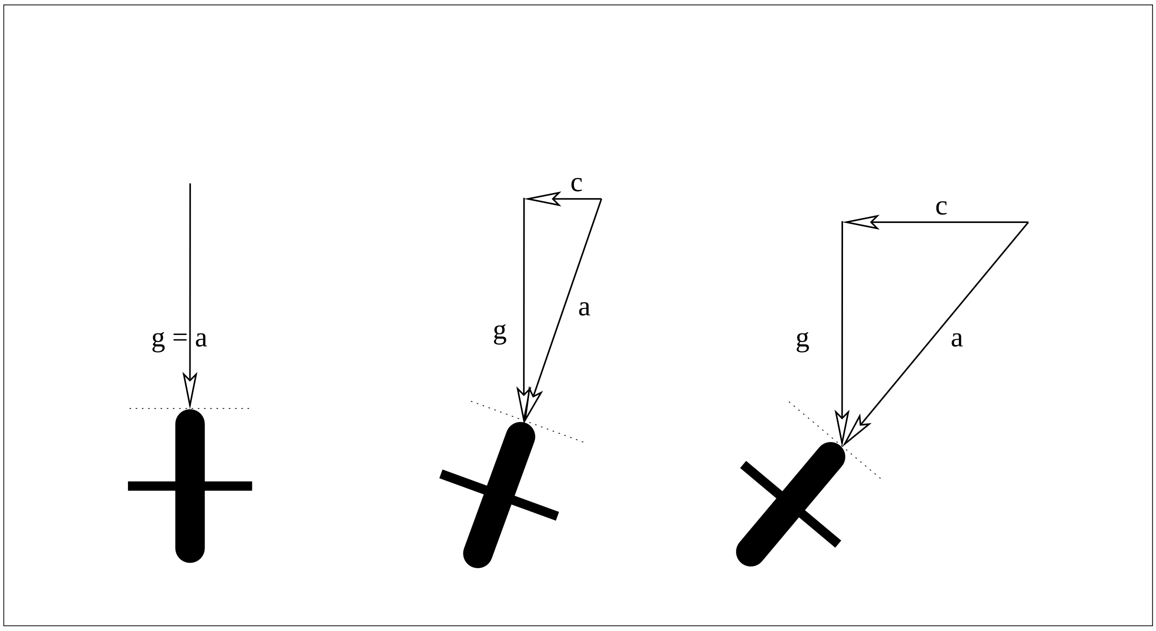

Figure 2: Lateral-force-controlled board

$R(t, v)$ of both tilt angle t and board velocity v in an tricky way to widen the speed range of such a steering mechanism. However, not a single mountainboard manufacturer has done anything like that until now. For a channel truck type steering $R = \frac{w}{2 * \sin \alpha} \cdot \frac{1}{\sin t}$, where α is the incline of the centre bolt of front and rear steering and w is the wheel base. The centrifugal acceleration c experienced by the rider in turn is determined by the absolute velocity v and the turning radius R. For a channel truck moutainboard steering we get:

$c(t, v) = K_b \cdot v^2 \cdot \sin t$

where $K_b = \frac{2 \cdot \sin \alpha}{w}$ is a constant determined by the boards geometry.

From the formula above, we can see that the effect of tilting the board ($\sin t$) is very close to what we would like to have ($\tan t$) for an optimal carving feeling. If riding at the right speed we can experience a nearly optimal carving feeling. However, from the formula above we can also see that the centrifugal acceleration is heavily dependend on the board speed. This is the reason for the well known speed wobbles of 4-wheeled boards. Once the rider gets faster than expected the board feels like over-steering all the time and difficult if not impossible to control.

3 Lateral-force-controlled boards

Lateral-force-controlled boards adjust the turning radius dynamically in a way that the lateral force becomes zero. In other words: the turning radius is adjusted so that all resulting forces point with a right angle onto the deck and wheel axis. This is independent of speed or the amount of tilt. In figure 2 we can see how gravity g, centrifugal force c sum up to a resulting acceleration a and that a (the riders tilt) aligns with the board tilt. Lateral forces would appear in direction of the dotted lines, but as mentioned before, the steering mechanism zeros these forces.

All 2-wheeled boards (windscooter, dirtsurfer, X-board, grassboard), (motor-) cycles, most of waterboards like surfboards, windsurfboards, kiteboards, waterskis but also snowboards in deep powder work like that.

For all 2-wheeled boards the formula for the centrifugal force is simple:

$c = g \cdot \tan t$

There's no dependency on the board velocity nor any board constant. We experience optimal carving feeling over the full speed range. All 2-wheelers are auto-adjusting steering sensitivity to speed and give the rider control over a really wide speed range. What can't be seen from the formula: this mechanism can only be used for a front wheel and all 2-wheelers are directional boards - you can't ride them backwards. While not strictly forbidden by theory its utmost difficult if not impossible to build a real, stable bidirectional 2-wheeler. Additionally it's - for most people - impossible to keep in balance at zero speed on a 2-wheeled board.

4 Non-board steering mechanisms

All vehicules not mentioned yet use a steering method independend of vehicule tilt: buggies, the kite-bike (2-wheeled!), land-yachts, boats, jet-skis, inline-skates and more. I won't talk about these any further as these mechanisms are not suitable for controlling a land-surfing board.

5 Comparison

Lets focus on comparing the deck-tilt-controlled boards (typically a mountainboard) to the lateral-force-controlled boards (typically a dirtsurfer/windscooter) now. The following shows some typical riding scenarios and the required board/deck positions.

5.1 Riding straight

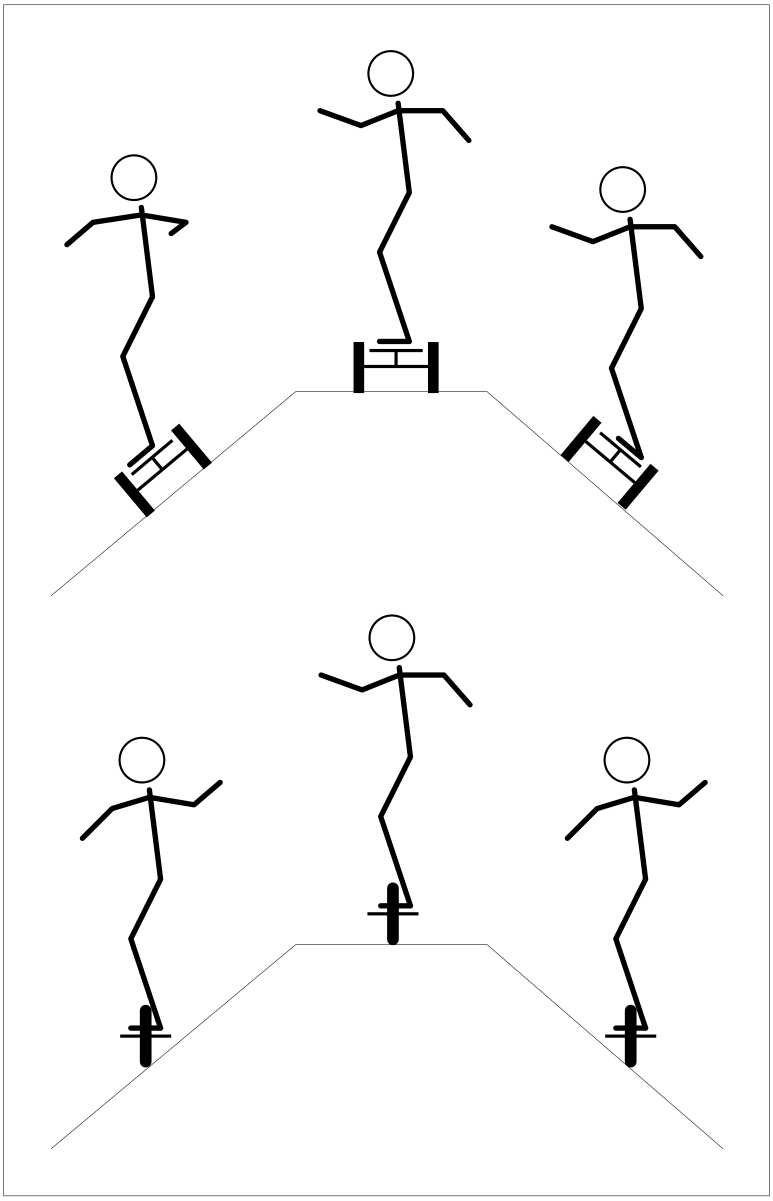

Figure 3: Riding straight

On the figure to the left we see how the two board types behave when the rider goes straight right towards the reader. The upper part shows a 4-wheeled board, the lower part a 2-wheeler. As you might expect, on horizontal ground both boards go straight, when they're held horizontally. This is shown in the middle. On the left we can see what needs to be done, if the ground is not horizontal, but leads down to the left. The rider of the 4-wheeler has to keep the deck (nearly) parallel to the slope, thereby pointing down the hill with his toes. For the rider of the 2-wheeled board, it does not make a difference - he's still keeping the deck horizonally for going straight. The right side shows the situation, where the ground leads down to the right. The rider of the 4-wheeled board has to keep the deck parallel to the slope, but this time his heels point down the hill and foot straps can't prevent slipping off the board. The 2-wheel rider still keeps his board horizontally for going straight.

5.2 Turning

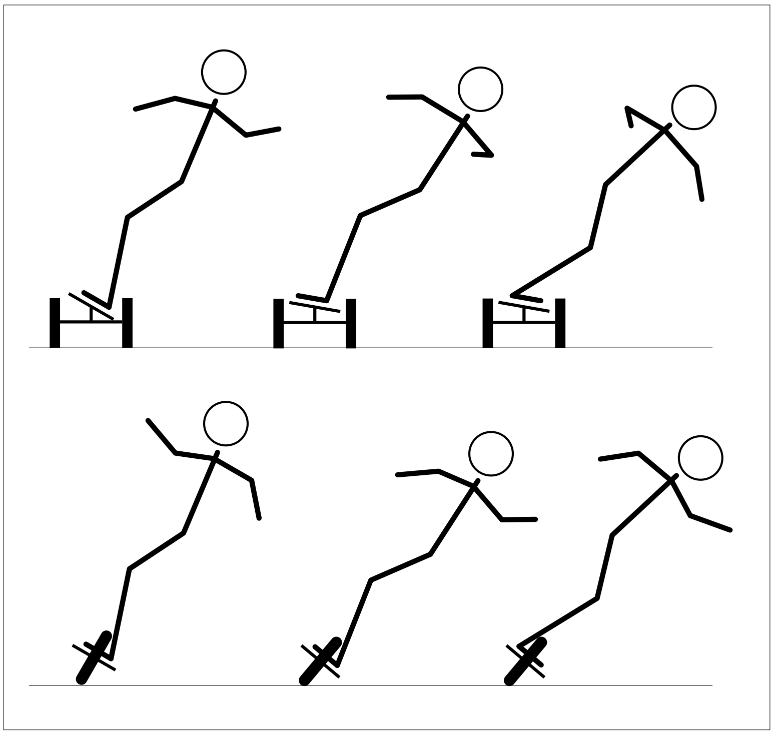

Figure 4: Turning

On the left we see the behaviour of the boards when turning to the right. In the upper row we see the deck-tilt-controlled board in action. The left part shows the board at optimal speed: the rider stands relaxed on the deck and his/her tilt matches the deck tilt well. The middle and right part shows a backside turn and a frontside turn at high speed. Due to the fixed dependency between turning radius and board tilt, the board tilt no longer matches the rider's tilt. The rider has to bend his ankles to equalize the tilt difference. This can be especially uncomfortable with the frontside turn as a human ankle has only a limited range of bending upwards. Additionally the boards surface must prevent the rider from slipping off by the lateral force - good grip tape or bindings are a must.

The lower part shows a lateral-force-controlled board under the same conditions. The steering mechanism adjusts the turning radius to the riders tilt and the board tilt equals the rider's tilt exactly - no matter if the speed is low or high. As the lateral force is zero, there's no danger of slipping off the board.

5.3 Traction kiting

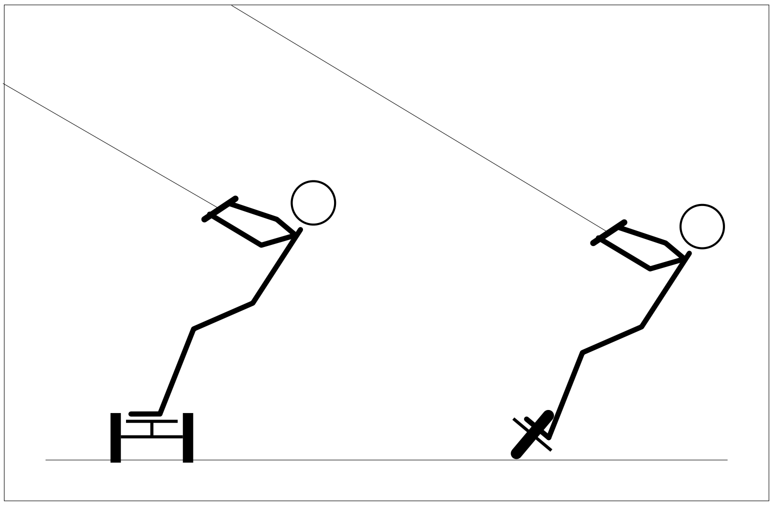

Figure 5: Traction kiting

The figure on the left shows landsurfing boards used for traction kiting. Both rider go straight with locked kite position. The left board is again a deck-tilt-controlled board. To go straight, the deck needs to be heldhorizontally, while the rider is pulled to the left by the kites considerable force. Grip tape and/or straps are used to prevent slipping off the deck. On the right side a lateral-force-controlled board is used. Again the riders body axis and the board form a right angle and the rider is able to stand relaxed on his feet. He's edging the board against the ground like he would do with a kite-board on water.

6 Summary

6.1 Deck-tilt-controlled boards

Deck-tilt-controlled boards (mountainboards in most cases) are mostly bidirectional boards that perform well their optimal speed. Especially at higher speed they become uncomfortable and unstable. We can also see some flaws when riding non-horizontal ground or when used for traction kiting. Deck tilt and rider body axis don't align in most of the cases, unfortunately.

This should be the perfect board for a young rider, who like the ATB-typical moves and jumps. This kind of board is also necessary for a kitesurfer who wants to ride on solid ground, too, and who really insists on going forward and backward with the board.

6.2 Lateral-force-controlled boards

Lateral-force-controlled boards (windscooter and similar ones) are directional boards that perform well over a very wide speed range and feel close to typical water sports boards. Especially at the high speed reached while traction kiting they feel stable and save. Their downside is their instability at zero speed and the lacking possibility to go backwards.

This should be the perfect board for riders who prefer freeriding and carving the hills to the latest freakiest tricks. A land surfer who likes the speed, jumps and the 'surfing feeling' needs to select one of these boards. People with watersports experience will feel comfortable with a lateral-force-controlled board.