Technic Automation

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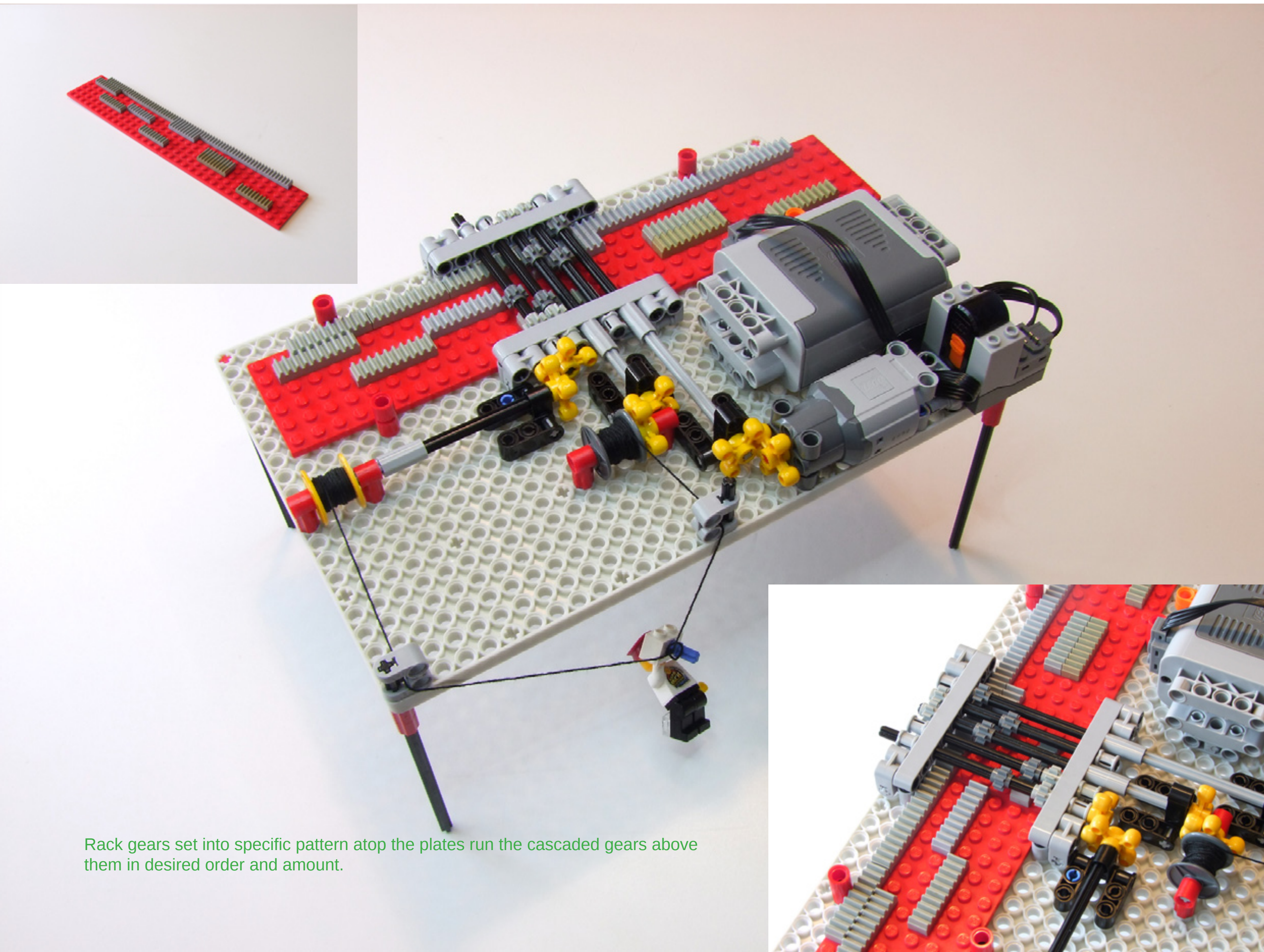
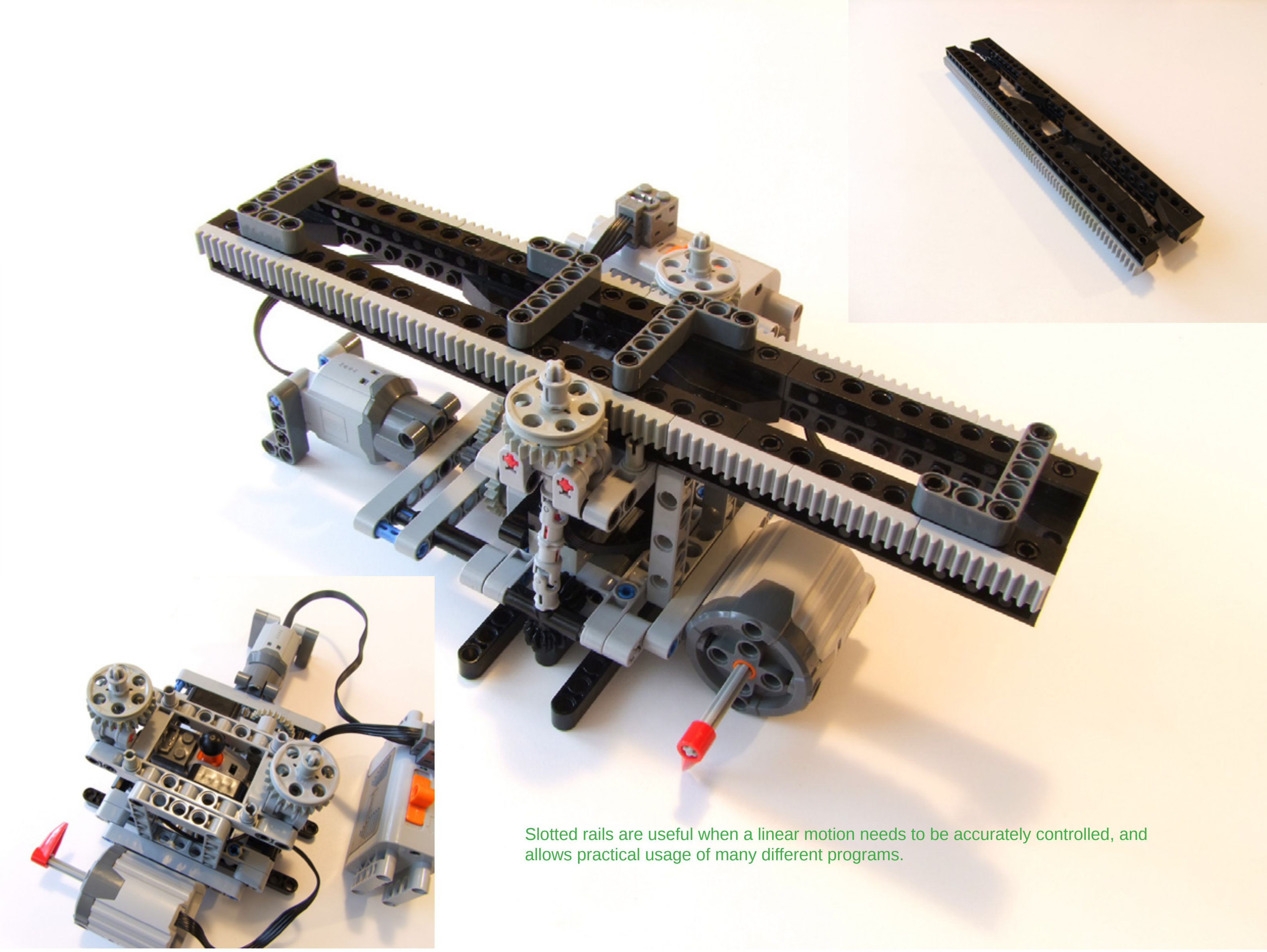
Technic models involving large complex processes, such as the Great Ball Contraptions, robots, etc. often require some sort of mechanical automation to work as intended. Typically it involves various movement sequences with precise timing and mechanical accuracy. It is tempting to solve these sequences using MINDSTORMS with its convenient programming and easily controlled motors, but some may prefer a mechanical solution — either for Technic pureness, or if MINDSTORMS is not available. In this article we shall take a look at a few basic methods for mechanical automation that can be easily modified and developed further according to their purpose.

The choice of methods depends largely on what type of automation is required: single or recurring. Single automation runs a mechanical program of movements only once, and usually allows the programs to be easily modified or replaced mechanically. Recurring automation, however, repeats a single program in loops as long as it is powered, and is normally not as simple to change on-the-fly. Both approaches allow running the programs backwards, and regulating the execution speed by changing the rotation speed of the automation drive, either manual or motorized.



Rack gears set into specific pattern atop the plates run the cascaded gears above them in desired order and amount.



Slotted rails are useful when a linear motion needs to be accurately controlled, and allows practical usage of many different programs.

Single run automation

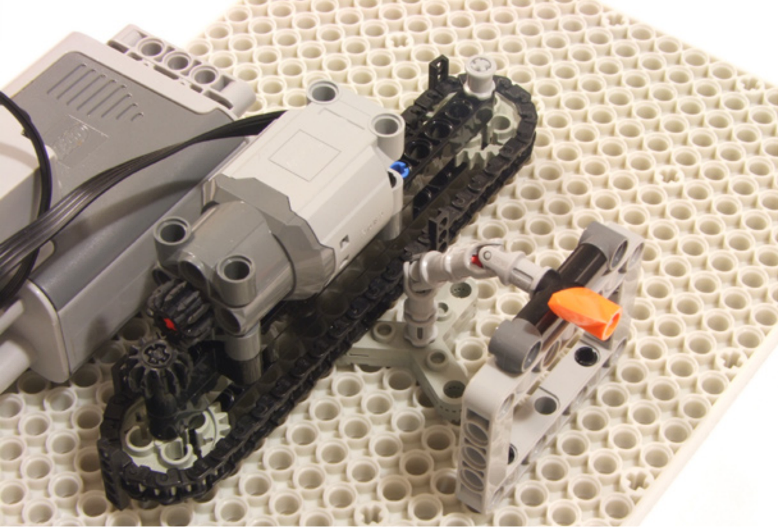
Let us begin with single automation, specifically with the rack gear plates — a simple and reliable method that appeared in the official Technic Idea Book 8888 over three decades ago. It consists of standard, connected plates of fixed width with rack gears atop, sliding under a cascade of gears they mesh with. By changing the position and density of rack gears, timing of movements can be easily adjusted. Typically, one of the rows of gears will be continuous and used to provide drive, i.e. to slide the entire plate under constant speed. Longer programs can be built by connecting multiple plates together, and reverse rotations done by having separate rows for each direction, connected via extra gears elsewhere, as shown in the photos. Apart from its reliability, additional advantages of rack gear plates are the ability to easily include as many independent outputs as necessary (by adding multiple rows of rack and receiver gears), have them well synchronized between themselves, and keep the mechanism relatively small yet strong.

Rack gear plates are a good idea if rotation is what one requires at the output of the automation. However, if it needs to accurately control a linear position, such as flicking switches or moving levers, slotted rails may be more useful. They usually consist of two parallel main beams, held at a fixed distance using perpendicular beams, with sloped bricks forming a narrow, squiggly slot in between. If slid lengthwise across a switch or a lever that fits in the slot and moves perpendicularly, it will move the switch through desired positions according to the shape of the slot. This sliding action can be done whichever way one prefers, though the aforementioned rack gears can be of use here as well.

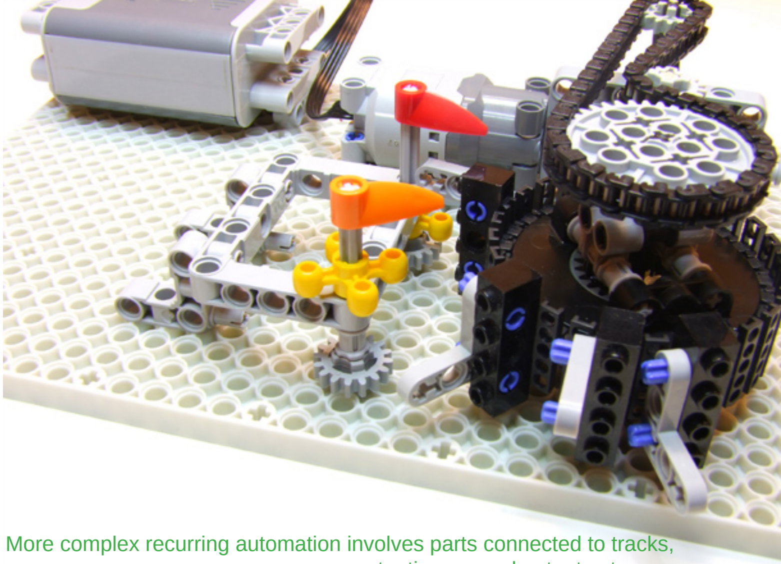
One needs to pay attention to the receiving lever design, as it should not have any kind of edges that may halt the rail — various towball parts serve nicely for this purpose. In addition, the tighter it fits in the rail slot, the more accurate automatic movements can be achieved. Multiple synchronized movements can be made by connecting more than two main beams, and building a slot between each pair.

Recurring automation

TLG has provided components that serve useful for recurring automation, i.e. where the movements are repeated. Those are Technic chains and track treads, both of narrow and wide type. The simplest approach is to build a regular Technic chain with several narrow track treads replacing chain links where necessary and have it run in a motorized loop. With a bit of adjustments, it is possible to let each of the occasional passing treads turn a knob gear underneath by about 90°. Additional movements can be controlled by running multiple chains simultaneously on a common sprocket axle, although that takes a lot of space and requires plenty of supporting structure.



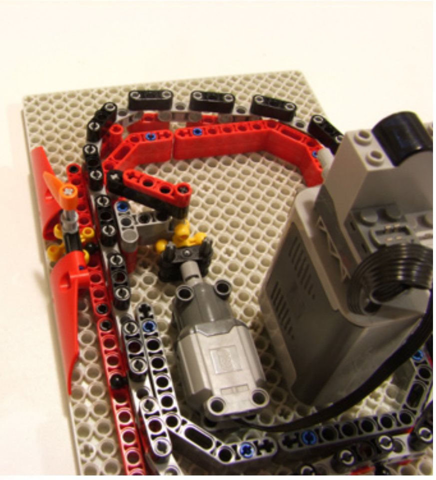
Interchanging regular chain links and track parts can control timing of the knob gears positioned underneath.

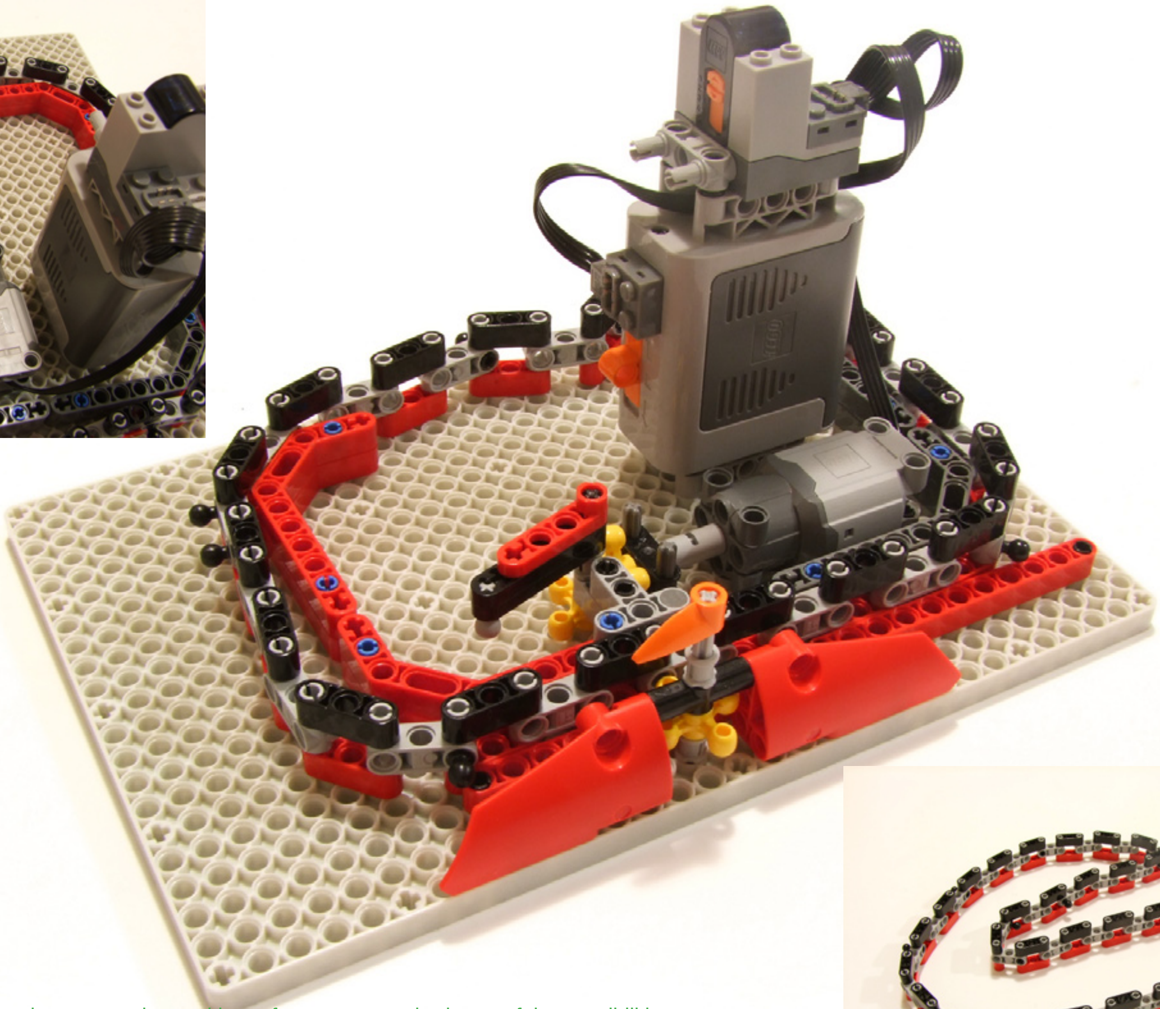


More complex recurring automation involves parts connected to tracks, actuating several outputs at once.

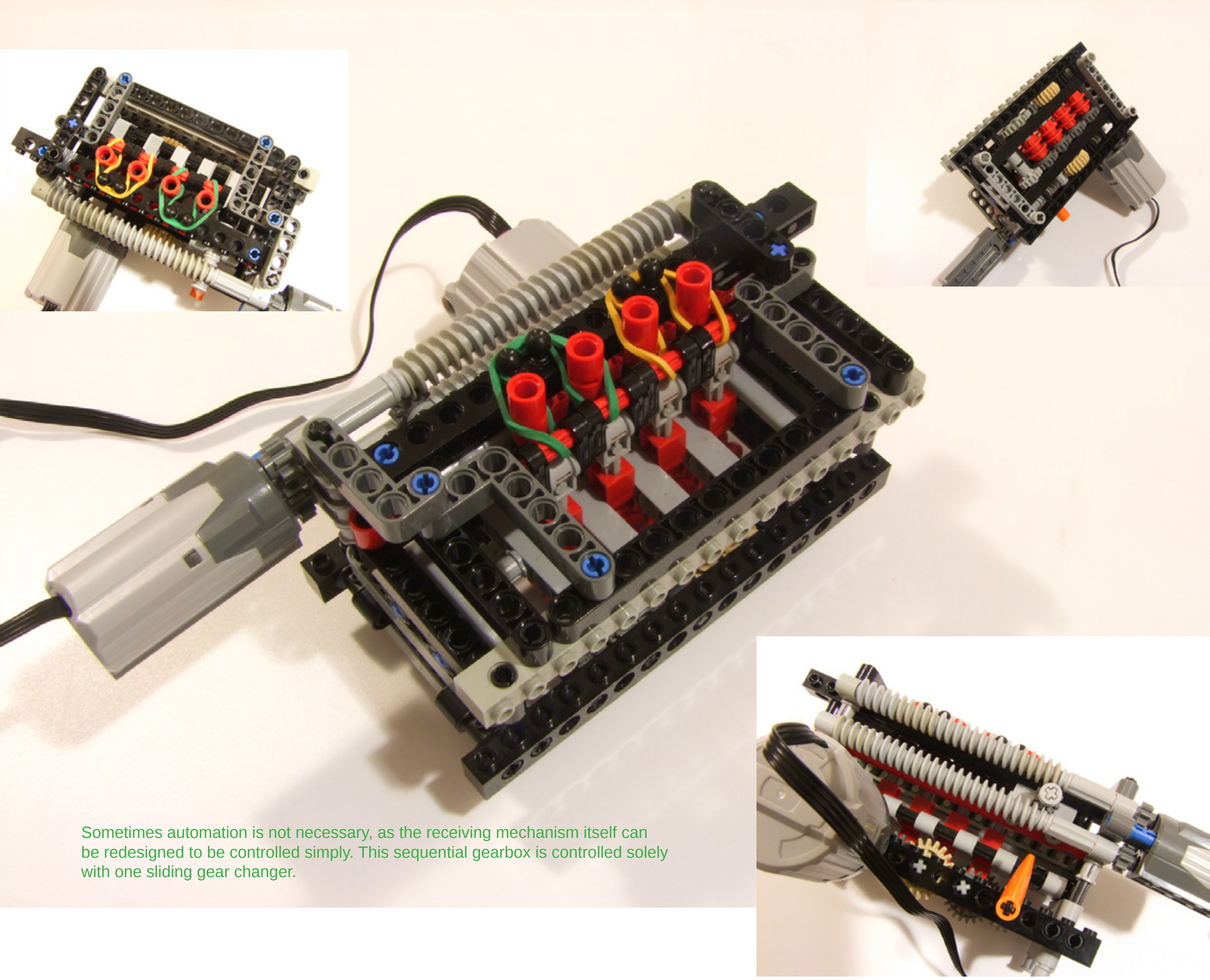
This problem can be avoided by going for a more sophisticated solution — mounting additional parts on track parts themselves. Parts such as four stud wide plates or Technic bricks fit atop the narrow tracks, while the wide allow connection to almost any Technic part thanks to their pin holes. These extra parts can vary in shapes and operate multiple gears, levers, switches, etc. along their way.

While these recurring automation ideas work well for small forces, they are not sturdy enough (especially not the narrow tracks) when considerable mechanical strain is involved. In those cases, one can build a wide, strong chain from pins and beams, as these can withstand considerably higher strain and handle more power, in exchange for larger dimensions and more complex driving mechanism. There are many ways to employ them for automation, with ball pins and knob wheels being among the simplest and most reliable. In fact, they are particularly useful for many types of Technic automation.





When recurring automation and large forces are required, one of the possibilities is to build a custom chain.



Sometimes automation is not necessary, as the receiving mechanism itself can be redesigned to be controlled simply. This sequential gearbox is controlled solely with one sliding gear changer.

Things to keep in mind

You may have noted that all these concepts share a common trait: they do not lock their outputs at the time they are not actuated, e.g. a wheel driven by the occasional track tread in a running Technic chain can rotate freely when not meshed with it. Locking mechanisms are doable with pure Technic as well, but are more complex than even the automation itself and of limited reliability. Instead, a more practical approach is to connect the outputs to worm gears that keep their follower gears locked at all times.

In the case you intend to develop your own custom Technic automation, these examples hopefully display the basic concepts that are typical for any mechanical automation, even beyond LEGO®. There is always at least one component, such as a slotted rail, rack gear plate or a chain in displayed examples, that serves as a data carrier. When the mechanism runs, it is "scanned", usually by it being driven or moved in a certain way across a receiver mechanism that gets actuated at the programmed time by whatever way the data is embedded into the carrier. In our cases, those are sloped bricks in a rail, track treads in a chain, or rack gears on the plates set into patterns that correspond to desired output movements and timings.

Mechanical automation can be developed to great lengths and perform amazingly advanced tasks, but one should keep in mind that it makes sense only if such advanced operation is required in the first place. On the other hand, if the starting requirements are rather simple, the entire cumbersome automation can often be substituted by a well-adjusted crank or some clever type of linkage. In addition, the receiving systems can often be redesigned to simplify their control. For example, sequential gearboxes, if built in the common manual H-pattern as in most cars, require various programs controlling horizontal and vertical gear changer movements. However, as shown on the photo, gearboxes can be designed to have gears changed simply by moving a sliding changer across a liftarm, controlled with a single motor without any need for advanced automation — a linear movement is all that is required.

Finally, all automation examples from this article can be seen in action at the following address: youtu.be/-mYP01sohdo.
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