## Project GENESYS

# Robot the Porter

KIT Researchers Work with Industry to Develop an Airport Baggage Unloading System

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**R**obots are known to repeat lots of recurring defined sequences during production processes. This is quite different when they are based on GENESYS, or GENEric unloading SYStem, a joint project of KIT's Institute for Process Control and Robotics (IPR) and an industrial partner that is supported by the Federal Ministry of Education and Research. GENESYS provides the basis for using a robot to unload air baggage. Co-developer and group head Dr. Björn Hein believes that the passengers' bags and suitcases will be in good hands with a robotic "porter" under the command of that novel system.

Airport cargo personnel can tell you a thing or two about it: Unloading airplanes is a physically demanding job causing problems such as back and spinal disorders. With everybody hurrying and hustling, baggage unavoidably gets torn while being dragged around and treated roughly. GENESYS definitely is the gentler baggage handling option: The robot works continuously, grips the baggage carefully and cautiously, and facilitates possible baggage tracing operations. In addition, GENESYS-based solutions are conceived to instantly retrieve any robot-handled suitcase from among the heaps of baggage piled up in a baggage container. If an airline passenger fails to appear with his baggage having already been stowed, GENESYS can find and unload the respective bag or suitcase much more rapidly than could any of the cargo personnel. "Passengers are actually not aware of the presence of GENESYS at the airport," explains Dr. Björn Hein, who heads a group within this three-year project. It was initiated by a Karlsruhe company, Grenzebach Automation GmbH, that manufactures baggage handling robots for airport operators. GENESYS has a total budget of three million Euros about half of which has been contributed by the Federal Ministry of Education and Research.

GENESYS works well thanks to joint efforts made by Dr. Hein, institute head Professor Heinz Wörn, and two PhD students, Benedikt Kaiser and Ricardo Tauro. What sounds so easy in theory, in practice demands complex algorithms. To unload a container, a robot must be capable of orienting itself, of gripping bags or suitcases of any weight, and of avoiding deadlocks. Indeed, GENESYS can provide assistance and is expected to be versatile and to take on to a variety of tasks at airports and in locations with similar requirements.

The team of researchers was confronted with lots of questions: How does the robot distinguish a suitcase from a container wall, how can it develop a variable unloading strategy or plan collision-free tracks? Roughly, the sequence of very precise commands is as follows: Delivery of a piled-up baggage scatter-plot by a 3D sensor, collision-free grip point determination by the robot, initial movement of the gripper arm, gripping of baggage by means of the vacuum gripper of the gripper arm.

*Careful: The robot grips the baggage cautiously.*

*Vorsichtig: Der Roboter greift das Gepäck behutsam.*



*Fast: GENESYS finds bags or suitcases very rapidly.*

*Flink: GENESYS findet Taschen und Koffer sehr schnell.*

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**Björn Hein**

A force-moment sensor gives a signal to the robot in case it drops or loses a bag or suitcase. "The robot generates its own track," Björn Hein says to elucidate the great difference between GENESYS-based baggage handling and conventional production robots. Different track planning algorithms are started simultaneously to rapidly select the best mode of inducing the gripper to move and hold on to the baggage piece with its six joints.

GENESYS was modeled after human personnel. The strategy of baggage handling applied by the staff was imitated and adopted by the robot. GENESYS is capable of both unloading baggage containers of the kind used in large airplanes and roll containers of the kind used to transport the baggage coming from smaller planes. While the respective algorithms were developed at the institute, the industrial partner set up a demonstrator to give examples of the system's functionality and operation.

The Institute for Process Control and Robotics has investigated both the fully automatic and the interactive mode. The latter is based on integration of a human operator who controls the unloading process at a safe distance from the robot. If, for example, the robot fails to identify a piece of baggage to be handled, the operator can mark the next piece in the pile using a touch screen or pointing device. This variant leaves the unloading strategy to human staff while charging the robot with carrying the load. "Completely new production concepts may develop based on GENESYS," says Hein, who assumes that the robot can close large gaps in airport logistics. Besides, robots generating their own tracks may move on, so to speak, to provide collision-free approaches to solutions for the automobile industries. ∎

# Der Kofferboy ist ein Roboter

## Entladesystem für Flughäfen

GENESYS (Generisches Entladesystem) heißt ein Verbundprojekt, bei dem das Institut für Prozessrechentechnik, Automation und Robotik (IPR) am KIT Partner zur Seite und eine Förderung des Bundesministeriums für Bildung und Forschung (BMBF) im Gepäck hatte. Das Projekt schafft die Grundlagen dafür, dass ein Roboter Flugzeuggepäck entladen kann.

Der Roboter arbeitet konstant, packt das Gepäck sorgfältig an, macht eine detaillierte Nachverfolgung der einzelnen Gepäckstücke leichter. Mit GENESYS wäre es denkbar, dass ein vom Roboter verladener Koffer in einem Gepäckcontainer unter 100 anderen sofort gefunden wird. „Der Fluggast merkt von GENESYS eigentlich nichts", sagt Dr. Björn Hein, Grup-

penleiter dieses dreijährigen Projektes, das bei einem Gesamtvolumen von drei Millionen Euro etwa zur Hälfte vom BMBF gefördert wurde. Initiator war die Karlsruher Firma Grenzebach, die Flughafenbetreibern bereits Roboter mit Beladefähigkeiten anbietet.

Gemeinsam mit Institutsleiter Professor Heinz Wörn und den Doktoranden Benedikt Kaiser und Ricardo Tauro hat Hein Algorithmen entwickelt und so dafür gesorgt, dass GENESYS funktioniert. Das Entladen eines Gepäckcontainers vermag ein Roboter nur dann zu bewerkstelligen, wenn er „sich orientieren", wenn er unabhängig vom Gepäckgewicht „zupacken" kann, wenn er Verklemmungen „vermeidet" und so arbeitet, dass er nirgendwo anstößt.

Ein 3-D-Sensor liefert eine Punktewolke des Gepäckberges, der Roboter nimmt eine kollisionsfreie Greifpunktbestimmung vor, der Greifarm setzt sich in Bewegung und packt ein Gepäckstück mit seinem Vakuumgreifer. Ein Sensor im Kraftmoment gibt ihm ein Signal, sollte er den Koffer verlieren. „Der Roboter erzeugt seine Bahn selbst", erklärt Björn Hein den großen Unterschied zu bislang eingesetzten Produktionsrobotern. Damit der Greifarm mit sechs Gelenken richtig zulangt, laufen verschiedene Bahnplanungsalgorithmen gleichzeitig an und wählen in Windeseile die beste Vorgehensweise aus.

INGRID VOLLMER